DECIMAL ARITHMETICK

Wherein the

Whole Art

Is made easy to any indifferent Capacity.

BY

Notation, *Addition*, { *Substraction*, *Multiplication*, } And { *Division*,

With several Variations.

ALSO,

REDUCTION, with the *Golden Rule*, or *Rule of Three*, shewing several wayes of Measuring Circles, Globes, Balls or Cylinders, &c. and to find the solid Content of any Butt, Pipe or other Cask Cones and their Frustums, with several waies of Measuring Taper Timber.

To which is added

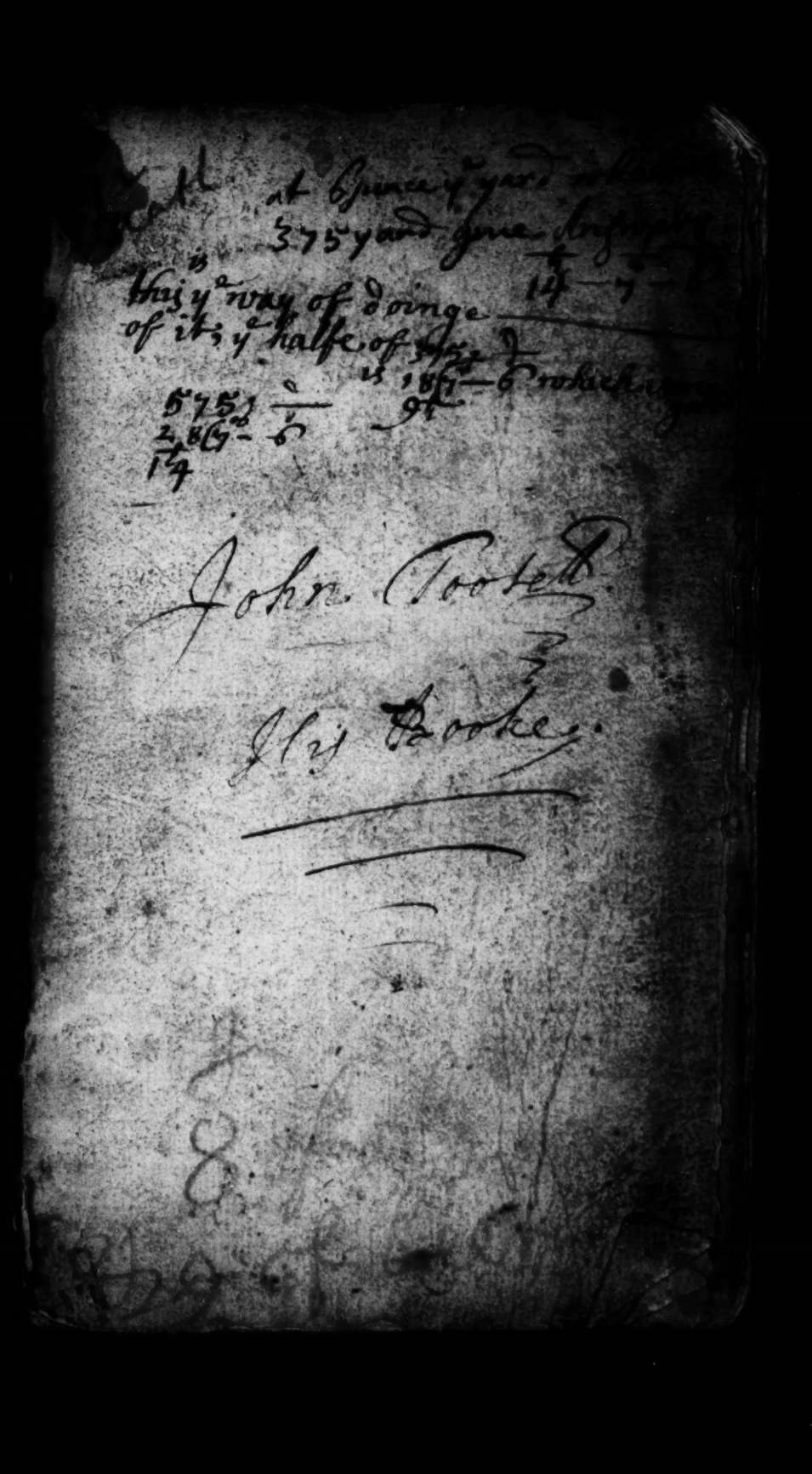
The Description of a very easy Instrument for the taking of any heights or distances without Geometry or Trigonometry, Scale Compasses or Line of Cords, only counting the Divisions of the Instrument, with the Explanation of the Multiplication of Decimal of vulgar fractions, the Rules of Practise in Decimals and so plain a way of Extracting the square Root almost as easy Division.

ALSO

An Essay to Gunnery, shewing several waies of finding any inaccessible Distance or Altitude, within common sight, with very many things never before made publick, of which you may Read at large in Page 103 & 104.

By *WILL. WALGRAVE.*

LONDON Printed for the Author and are to be sold by him at the Two White posts in Newton street in St. Giles's, and Mr. Walter Hayes at the Gross Daggers in Moor-Fields 168



Jonath. Moore Arithmetick vb good.

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Whole Art

To the Right Honourable

Sir THOMAS CHICHELY,

KNIGHT,

Master-GENERAL of His MAJESTIES ORDNANCE, and one of Hts MAJESTIES Most Honourable *PRIVY COUNCIL.*

HAVING Finish'd these Essayes, *I thought my self in Duty Oblig'd to offer them to your Honours Censure, whose Readiness to Entertain any thing that*

may Tend to your King and Countreys Service: together with your Love to Uſeful Sciences, has Emboldned me to this Dedication, and to Subſcribe my ſelf

Your Honours Humbly
Devoted

WILL. WALGRAVE.

TO

To the READER.

Courteous Reader,

I *Having for many years been Acquainted with ſeveral of His Majeſties Gunners and Practitioners, and being often invited by them to ſee their Exerciſe, which Created ſeveral Diſcourſes and Diſputes of Gunnery amongſt us: I was in the beginning of the Year* 1672. *deſired to be one of their Society. but Conſidering that the Nature and Form of the Oath taken by every Practitioner at his Entrance, is,* To ſerve his Majeſty by Sea or Land whenſoever he ſhall be Commanded, *I refuſed to take it becauſe my Conſtitution will by no means endure the Sea; But at length it was Agreed, that Clauſe ſhould be left out in my Oath, and then I took it.*

Not long after ſeveral of them Appointed a Place of Meeting, and deſired me to give them ſuch Inſtructions and Directions as were neceſſary for a Gunner to underſtand, which I condeſcended to, and in order thereunto Compoſed ſeveral

uſeful

useful Tables, never extant in any Author, with plain and easie Directions for the use of them, and many other things necessary to be known, by every one that intends fully to understand the Duty and Business of a Gunner; much more being required therein then to Dispart a Peece and Shoot at the Butt *in the* Old Artillery Ground.

But our Meeting being of no long continuance, and by that means few (or none) being made perfect in their Business, I was desired by several of them to Publish this following Treatise, it being Printed and Set forth at the Charge of my Loving and Candid Friend Mr. Richard Pyne, *for the benefit of such as are desirous of Instruction and Knowledge in that Art; Hoping the genuine and impartial Reader will kindly accept thereof, though (as it was long in doing, now and then by Peecemeals) there is not that Order and Method in it which by some Criticks may be expected; Which being Granted, will (perhaps) encourage me to amend my Copy another time, and oblige him that will be Ready to serve you to his Power,*

W. Walgrave.

ERRATA.

PAge 4. line 4 for *within* r. *which in*, ib. l. 6. for, *our* r. *four*. p. 10 l. 14. for *ſet down* r. *ſet down* , p 17 l 9. for 3 7. 18 5 over 25, p. 23. l. ult. for *an equal* r. *unequal*. p 34, l 26, for *right* r. *left* p, 39, l. 20. for *right* r. *left*. p. 51. l. 20. for *being ſubſtracted* r. *ſubſtracted from* p, 56 l, 20, or *produceth* 11 r, *produceth* 15 p 65. l. 23. for *pence half-peny* r. *7 pence half penny*. p. 80. l, 6, for *dividend* r, *divided*, p. 93 l. 8, for *root the* r. *root of the*. p. 94. l. 4. for *lolodity* r, *ſolidity*. p 97, l, 7, for *of the 3 foot* r, *of the baſe*, 3 *foot*, p 97 l, 8 for *top of* r, *top of*, p 103, for *ſell* r. *ſhell*. p. 112. l. 22, for 2057 r. 20 17. p, 122 l, 13, for *much reaſon* r, *much by reaſon*, p, 127 l, 12, for *at her bore* r, *of her bore*, p, 140 l, 1, r, *half of it*, p 15 , l, , r, *laid open*. p. 152, for *rule* r, *reſult*, ib l, 11, r, *cube root*, p, 156, l, 20, for *line* r. *limb* p, 160 l, 16, r, *having ſet*. ib. l. ult, for *unto which you work*, r, *unto which if you work true*, p 169, l, 14, for *acceſſible* r. *inacceſſible*. p, 177, l, 3, for *left* r, *right*. p, 178, for *acceſſible* r, *inacceſſible*,

Faults in the TABLES.

In the Table of Coyn under Farthings for 4, r. 1 penny.

In the Diſparting Table, againſt 39 and under 6. for 10. r, 12, and againſt 41 and under 2, for 13, 1 6 r. 13 : 114. and under 3 for 13 : 178 r. 13 : 146. and under 4, r, 13 : 1 8 and under 5 r, 13 : 209, under 6 r, 13 ; 241. under 7, r, 13. 273. under 8 r, 13. 305.

In the Table of Powder againſt 2 and under 4 for 28 r, 23.

In the Table of bredth of the Cartridg againſt 7 and under 7 for 24.00 r. 24. 20.

And in the length of the Cartridg againſt 3 and under 6 for 3.053 r. 3.053, and againſt 6 and under 2 for 1,629 r. 1,079.

In the Table of Gunnery in page 148 againſt D, C, and under the bredth of the Cartridge for 13,00, r. 13,20.

In the Tables for Finding Diſtances againſt 46 and under 2 for 010128 r, 010428.

And

Faults in the TABLES.

And against 67 and under 5 for 024262 r. 024142, and against 73 and under 8, for 034400 r. 034420.

These Tables should have been Printed as the Sines and Tangents are, to Lie open one against another, but you may have the same use of them by turning over a leaf.

Decimal

DECIMAL ARITHMETICK *Made Eaſie.*

THE Uſe and Excellency of this kind of *Arithmetick*, is not ſo well known as I could wiſh it were, and eſpecially in all kinds of *Menſuration*, either *Length*, *Superficial*, *Cubical* or *Liquid*.

For in taking the *Dimenſions* of any thing to be meaſured, there are no *Rules* that will come ſo near to Truth, as thoſe that are divided *Decimally*. Thus:

As if it be a Foot-*Rule*, it is divided firſt into ten Parts, which are call'd *Decimal-Inches*; or ſo many tenths of a Foot; then every one of theſe tenths are divided into ten Parts more, which bringeth the Foot into one hundred equal *Diviſions*, ſo that every Foot is call'd one hundred.

So, if you were to expreſs in writing, three Foot, and three of theſe tenths of a Foot, and alſo three tenths of one of theſe Inches: It is thus, 3. 33.

Which is no otherwiſe diſtinguiſh'd, then by

putting a ſmall point or tittle between the firſt Figure, and the two laſt, and then all the Figures beyond that Note of *Diſtinction*, are always *Decimal Fractions.*

Which is thus Expreſs'd, three hundred and thirty three Parts of one hundred.

And what hath been ſaid of the Foot, will be the ſame of the Yard or Ell, divided into an hundred Parts.

Addition of Decimals.

(1)	(2)	(3)
57. 24.	365. 873.	7864. 8573.
43. 52.	083. 190.	8756. 9257.
35. 87.	573. 287.	6834. 7301.
48. 72.	601. 892.	8020. 6002.
69. 35.	710. 785.	0730. 0503.
254. 70.	2335. 027.	32207. 1636

THE *Addition of Decimals* differeth nothing from other Addition of whole Numbers, but minding the Fractions that are pricked off towards the right hand; The ſum of the firſt five lines, of Figures under (1) is 254 and 70

70 Parts of an hundred; The ſum of the ſecond under (2) is 2335 and 27 Parts of a thouſand; Alſo the third ſum under (3) is 32207 and 1636 Parts of ten thouſand.

The firſt Parcel, the Fractions are but in hundredth Parts; as we ſuppoſe a Foot or a Yard to be divided into ſuch Parts.

The ſecond Parcel, the Fractions are Parts of a thouſand; as if a Foot or a Yard were divided into a thouſand Parts.

The third Parcel, the Fractions are Parts of ten thouſand; as if a Foot or a Yard were divided into ſo many Parts.

Subſtraction of Decimals.

SUBSTRACTION is the taking of one Number out of another; as thus, four taken from ſix, and there remains two, and eight from twelve, there will remain but four.

The order of *Subſtraction* of *Double Numbers*, is to borrow from the next Figure towards the left hand, when the upper Figure to the right hand, is too little to take the other Figure out of.

As in taking eight out of twelve, when they are

ſet in order to be Subſtracted, and will ſtand under the ſecond, and I cannot have eight out of two, but then borrowing one from the next place on the left hand, within that place is ten, then I ſay eight from twelve, and there remains four.

This Rule you muſt obſerve in all *Decimal Subſtraction*, for this kind of *Subſtraction* is much eaſier than the Subſtraction of *Time* or *Money*; for they have ſeveral Denominations, but this goeth all by tens, as whole Numbers do; keeping the true places of the Fractions.

78. 44.		878. 753.	
64. 32.		789. 987.	
14. 12.	Difference.	88. 766.	Difference.

The proof of this Work, is by Adding the difference, and the ſum that you Subſtracted out of the uppermoſt, together; and if it be true done, it will be the ſame with the Number that you Subſtracted from.

Example.

64. 32.		789. 987.	
14. 12.	add	88. 766.	add
78. 44.		878. 753.	

This

This proves the work to be true, for by this Addition you may ſee both your ſums that you Subſtracted from, produced; *viz.* The firſt 78. 44. And the ſecond, 878. 753.

This is very eaſie, and but little uſed in Gunnery; and thoſe that have occaſion may find it at large in *Mr. Liburns Arithmetick*, in page 246.

Multiplication in Decimals.

THE Uſe of the foregoing *Table*, is to know how much any Figure, being multipli'd by another Figure, contains.

The firſt Column at the left hand, and the uppermoſt Rank of Figures at the top, are the leaders of all the reſt of the *Table*.

For if you would know how many times ſeven times eight is, always look for the greateſt Number at the Head of the *Table*, and againſt the other in the firſt Column, and in the angle of meeting, you will have your deſire.

Firſt, I look for eight at the Head, and guideing my eye downward, till I come to ſeven in the firſt Column, and under eight (which is at the top) in the Angle of the meeting of eight and

ſeven, I find 56, and ſo much is ſeven times eight or eight times ſeven.

The like is to be underſtood of any other Figures, as nine times ſeven is 63, or ſeven times nine, is all one, and ſeven times ſeven is 49, and eight times eight is 64, ſo nine times nine is 81; And theſe laſt Numbers are the ſquares of the Figures at the Head, and thoſe in the firſt Column, as ſix at the Head and ſix at the Side, is 36 in the Angle-meeting; and ſo much is the ſquare of ſix, and in the ſquare of five is 25, and the like is to be underſtood of all the reſt.

Multiplication of Decimals.

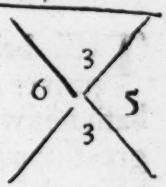
THIS is the Principle, and moſt Uſeful belonging to *Decimal Arithmetick*, and in all ſorts of Menſuration it is moſt proper.

Multiplication is a doubling, or ſeveral times adding of one ſum; Multiplying any Number by two, is but doubling the ſame Number, and if you Multiply any thing by three or four, it is but ſetting down the Number three or four times, and adding them together; and their ſum will be the ſame, as if it had been Multiplied by three or four. For

For if ten were to be Multipli'd by three then I ſay three times 0 is 0, and three times one is three, which being ſet on the left hand the 0, it will be 30, ſo likewiſe if you ſet down ten three times, and add them together, it alſo will be 30, and ſo will four tens be 40; The like muſt be underſtood in greater Numbers.

Multiply 23 by 564, as in the Margent, then ſay three times four is twelve, ſet down two under three, and carry one in your mind; then ſay three times ſix is 18, and 1 that you bear in mind, makes the 18 to be 19, ſet down nine and carry one, and three times five is 15, and one is 16; ſet down ſix, and the 1 behind it, as in the Example.

564.
23.
1692.
1128
12972



Then have you done with the Figure 3, and you may give it ſome note, that you may know you have done with it.

Then begin with the 2 which is under 6; and ſay two times four is eight, which you muſt ſet under the 9: For always when you begin to Multiply with any Figure, you muſt ſet the firſt Figure under it; for as the Figure 2 ſtandeth under the 3, ſo muſt the 8 ſtand under the 2, which you Multiply with.

Then ſay two times ſix is twelve, ſet two under ſix, and keep one in mind, then two times five is ten, & one in mind is eleven; ſet one under one, and the other one further to the left hand; then draw a line and add them together as you ſee, 12972. So have you finiſhed this Multiplication.

How to prove Multiplication.

THE beſt way is by *Diviſion*, becauſe it proves every Figure thereof: But he that hath not well learned Muliplication, will be at a great ſtand how to prove his work by *Diviſion*, before he underſtands any thing of it.

But here is another way, which may be eaſily learned, and quickly done. Thus,

Firſt, make a Croſs, as you may ſee at the laſt Figures Multipli'd; then ſee how many nines you can have in 564; thus five and ſix is eleven, and four is fifteen, out of which fifteen take nine, and there remains ſix, which I ſet in one ſide of the Croſs; then caſt away all the nines out of the next Number, *viz.* 23, ſaying two and three is five, ſo there is no nine at all,

all, then ſet this five in the Croſs, over against the ſix, then Multiply five by ſix, and it makes 30; now caſt away all the nines of 30 (which is three nines that makes 27) now 27 from 30, and there remains three, which ſet at the Top or Bottom of the Croſs.

Then caſt all the nines out of the Product, which is 12972, ſaying one and two is three, and nine is nine, then ſeven and two is nine; ſo when two nines are caſt out, there will remain but three, which you muſt ſet at the bottom of the Croſs, and always when the top and bottom Figures are alike, then the work is true done, otherwiſe not.

Multiplication with Decimal Fractions.

LEt the length of a Plat-form to be Paved with *Purbick* ſtone, be 33 Foot and ſeven tenths and a half, which will ſtand thus, 33. 75; And ſuppoſe the bredth to be 31 and 53 parts of a hundred; I would know how many Foot of Stone there will be in the Paving of it.

Here

Here Note, that here is two Fractions in the length, and two alſo in the bredth, which is four Fractions in all; and ſo many Fractions muſt be cut off at the right hand, when you have Multiply d them one by another, as you did the whole Numbers in the laſt Example, ſet them down.

Another Example.

33.75
31.53
10125
16875
3375
10125
1064.1375

Always ſet the biggeſt Number uppermoſt, then begin with the laſt Figure of the lower Sum, and ſay 3 times 5 is 15, ſet down 5 and carry 1, and 3 times 7 is 21, and 1 I carried is 22, ſet down, and carry 2, and 3 times 3 is 9, and 2 carried is 11, ſet down 1 and carry 1, and 3 times 3 is 9, and 1 I carried is 10, which I ſet down, it being at this end of the Multiplication of the firſt Figure.

Then I begin with the next to it, which is 5, and ſay 5 times 5 is 25, I ſet down 5 and carry 2, as you ſee in the Example.

And by the ſame Rule proceed as with 3 and 5, and after the ſame manner with all the reſt of the

the Figures, always falling one place back towards the left hand, that the firſt Figure that you ſet down may always ſtand under the ſame Figure that you Multiply by; Then when you have compleated all the four Figures right, they will ſtand in the ſame Order, as in the Example, then add them together, and their ſum will be: 1064: 1375.

Then cut off the four laſt Figures to the right hand, and thoſe will be Fractions; and the other four towards the left hand are the number of Feet, and the Figures cut off are 1375 Parts of 10000 of a Foot, which may be reduced into Inches, by being Multiplied by 12, and four Figures being cut off, as in this Example,

	1375
It will produce 1 Inch and 65	12
Parts of one hundred of an Inch.	2750
For in Decimals you are to	1375
underſtand, that 65 parts of an	1:6500

hundred hath the ſame Proportion as 6500 parts of ten thouſand, for Ciphers are added, and likewiſe taken away at pleaſure.

As thus, 5 tenths is the ſame with 50 parts of an hundred, and ſo is 500 parts of a thouſand, equal to 5 tenth parts, they being each of them equal halfes of their Denominator: ſo where Ciphers happen, you may leave them off as you pleaſe.

And

And by this laſt Example any *Superficies* may be Meaſured, not only in *Foot*-Meaſure, but alſo in *Yards*, *Ells*, *Paces*, *Poles*, *Chains*, or any other ſort of Meaſures, they firſt being divided into ten, a hundred or a thouſand parts, as you think convenient.

How to Meaſure Solids.

IF there were a Rampire or Bank of Earth to be made 40 yards long, 14 yards thick, and 22 yards high, (theſe are all even yards, and therefore it is the eaſier.)

Firſt, Multiply 40 by 14 thus: and the *Superficies* is 560 yards, which you muſt multiply by the height 22 yards, as in the Example, and the Product will be twelve thouſand three hundred and twenty yards, the quantity of the bank.

```
  40
  14
 160
 40
560
 22
1120
1120
12320
```

The Reaſon why this Queſtion was Placed here is, becauſe it oft hapneth that ſuch kind of Work is agreed for with Workmen at a Rate, by the yard.

And

Eights : Decimals of a Foot.

1	0104
2	0208
3	0312
4	0416
5	0520
6	0624
7	0728

Inches : Decimals. *Page 12*

1	0833
2	1666
3	2500
4	3333
5	4166
6	5000
7	5833
8	6666
9	7500
10	8333
11	9166
12	10000

And by what hath been ſaid in this, you may underſtand that the Meaſure will be the ſame, in the Digging forth of Earth for Mining o Countermining.

A Table to Reduce common Inches and Eights into Decimals of a Foot.

THE Uſe of this Table is to turn common Inches and Eights into Decimals of a Foot, for the ready Multiplying of Feet, Inches and Eights, when reduced into Decimals Fractions of a Foot.

This Table hath two parts: The firſt Column to the left hand of the upper part is Eights of common Inches; And the firſt Column of the lower part is common Inches: And the ſecond Column of both contains the Decimals, anſwering to Inches and Eights, as near as is needful for any common buſineſs, the uſe whereof will more plainly appear by

Examples.

I would have the Decimal anſwering to 7. Inches

Inches, and 7 Eights of an Inch: If you caſt your Eye on the lower Part of the Table, and againſt 7 Inches you may finde 5833, and againſt 7 Eights in the upper part is 0728, which added together, makes: 6561, which is the Decimal of 7 Inches and 7 Eights.

And in like manner, the Decimal of five Inches and 3 Eights will be found to be 4478: And the Decimal of 11 Inches and five Eights, will be 9686, and ſo you may finde any other.

A Table to Reduce the Nails of a Yard into Decimals.

THIS Table will be of good Uſe, when any Number of Yards and Nails are given to be Multiply'd by the ſame kinde of Denomination, as the Compaſs of any Room of Wainſcoat, Hanging or Painting, or whatſoever is given in Yards and Nails; And alſo the height of the Room in Yards and Nails; The Decimals will make the Work the eaſier, as will appear by this Example.

The firſt Column to the left hand, is the Nails of

A Table to Reduce the Nails of a Yard into Decimals.

Nails:	Decimals of Nails of a Yard.
01	0625
02	1250
03	1875
04	2500
05	3125
06	3750
07	4375
08	5000
09	5625
10	6250
11	6875
12	7500
13	8125
14	8750
15	9375
16	10000

of a Yard, and the ſecond is the Decimals anſwering to each Nail; As againſt 12 in the firſt Column is 7500 in the ſecond; And againſt 8 in the firſt, is 5000 in the ſecond; And againſt 5 in the firſt, is 3125 in the ſecond: And all the Numbers in the ſecond Column, are the Decimal parts, anſwering to each Nail in the firſt.

Suppoſe a Room 17 Yards and 12 Nails about, and 3 Yards and 5 Nails high, the Numbers will ſtand thus 17:7500 and 3:3125, which Multiplied together, produceth 58:79687500, which maketh 58 Yards, and a little above three quarters of a Yard.

Another Example with Fractions.

I would have a Mine made 73 Yards and 75 parts of a hundred in length, and 5 yards and 25 parts wide; and the height thereof to be 2 Yards and 5 parts, then I would know how many Yards of Earth it may contain, and alſo how many Loads, (4 Yards making 5 Load.)

Here will happen five Figures that will be Fractions, *viz.* in the firſt Number 75 are two, and 25 in the ſecond make four, and the 5 in the third Number, (which is a half) make five

Fractions

Fractions in the whole: Then ſet them down thus:

73 : 75 : length
5 : 25 : bredth
36875
14750
36875
387 : 1875

73 : 75 : uppermoſt being the length of the Mine, and 5 : 25 the bredth, ſet next under it as you ſee in the Example

Then Multiply the length by the bredth, beginning with the firſt 5 on the right hand at bredth, ſaying 5 times 5 is 25, ſet down 5 and carry 2, then again ſay 5 times 7 is 35; and 2 that you carried is 37; ſet down 7 and carry 3, and ſo go on till you come to the laſt Figure on the left hand of the uppermoſt Row, then the Multiplication of that firſt Figure, will produce 36875, as they ſtand in the Example.

Then begin again with the next Figure 2, and ſo proceed with it as you did with the 5, ſetting the firſt Figure of the Multiplication under the 2, that you Multiply by, and the ſum thereof will be 14750, ſtanding a place back towards the left hand.

Then begin with the next and laſt Figure, which is the ſame with the firſt, and therefore muſt be the ſame ſum, only it muſt ſtand one place more backward then the laſt ſum, that ſtands

ſtands about it, towards the left hand, and it will be the uttermoſt figure towards the right hand.

Then as they are ſet, which is each ſum one place backward of the ſum, over it, add them together, and their product (cutting off the four laſt figures for the four Fractions) will be the number of Yards that are on the Flat: 387. 1875.

Then the Height or Depth being two Yards and a half; by which you muſt Multiply the former ſum, as you ſee them placed in this example.

387:1875	
25	
19359375	
7743750	
967. 968. 75.	

So the numbers of the Yards of earth will be 967 Yards, and the five figures cut off are a Decimal Fraction of one Yard, the Yard being ſuppoſed to be divided into 100000 parts.

This, or any other Decimal Fraction, may be reduced into Feet and Inches by Multiplication.

Note that a Yard *Solid* or *Cubical* is 27 Foot; for one ſquare Yard is nine Foot, for 3 times 3 is 9, and 3 times 9 is 27, the *Cube* of 3.

How to clear a Decimal Fraction.

ANY Decimal Fraction may be brough into a Foot, Feet or Inches, if it be at Fraction of a Yard, or of a Pace, which is 5 Foot, or of a Pole, which is 16 Foot and a half, or of an Ell, which is 3 Foot 9 Inches, any of theſe ſuppoſed to be Decimally divided, into 10. or a 100. or a 1000 parts, or more: Their Fractions may be cleared by Multiplication.

If a Yard in length have a Fraction thereof to be cleared; it muſt be Multipli'd by 3. And if it be a Pace in length, by 5; If a Pole, by 16 and a half, and an Ell, by 3 Foot and 3 quarters of a Foot, or 3: 75.

But if it be a Fraction of any of their ſquares. then you muſt Multiply the Fractions by their ſquares, as the ſquare Yard is 9 Foot: and the Ell by 14 Foot 0625.

Note that you muſt always cut off ſo many figures as you have Fractions at the laſt, and what

what remains to the left hand, is Feet, and the other to the right, is a Fraction of a Foot, which you may afterwards Multiply by 12 Inches, and cut off the number of Fractions, and what remains to the left hand is Inches, and the like of any other: the ſquare Pace is 25 Foot, the ſquare Pole is 272 Foot and a quarter.

And the like way you muſt uſe in the Cubes; but there will be little occaſion for any of the aforementioned Meaſures in their Cubes, except the Yard.

And to clear any of its Fractions, you muſt Multiply by 27 Foot, and cut off all the numbers of figures as the Fractions did extend to; And what remains to the left hand is Feet; and the figure cut off is a Decimal Fraction of a Foot, which you may Multiply by 12 Inches as before directed, and as by the foregoing Fraction will more plainly appear.

Example.

The Fraction before going is five figures 96875, as you may ſee in the laſt example, which being Multipli'd by 27, the product is 26: 15625 the laſt

96875.
27.
678125.
193750.
26:15625.

five figures to the right hand, are a Fraction of a foot; and the 26 to the left hand are ſo many ſeet, which is almoſt another Yard.

And if you would know how much that Fraction which is laſt cut off, contains in Inches, Multiply it by 12, the Inches in one foot, and cut off five figures again, as in the example.

That is 15625 Multipli'd by 12, produceth 1.87500, which is one Inch and almoſt another; or almoſt two Inches, for if 1875 had been 2000, then it had been juſt two Inches but now it wanteth 25 parts of a 1000, which in this buſineſs is but little conſiderable.

15625.
12.
31250-
15625.
1.87500.

Alſo you may caſt up any Dimenſions, either in Superficial or Solid Yards.

Then to find how many load are contained in 968 Yards (for this is very little leſs) it is uſually done by the Rule of Three. Thus ſtarting the queſtion.

If 4 Yards give 5 Load; how many Load will 968 Yards give.

But by reaſon we are yet but in Multiplication, I will here acquaint you, how to effect it by Multiplication.

Any number of Yards Multipli'd by 125, and the two laſt figures or Cyphers cut off towards

wards the right hand; what remains to the left are Loads, as you may ſee in this Example.

986 Multipli'd by 125, produceth 1210.00. then prick off the two laſt, which are Cyphers, and the remainder is Loads, according to that proportion of 4 Yards making 5 Loads; and the number of Loads will be 1210; but if the two Cyphers which was cut off had been 25, then it had been a quarter of a Load, and if it been 50, then it had been half a Load, and if 75 it had been three quarters of a Load.

	968.
	125.
	4840.
	1936.
	968.
	1210.00.

Or you may clear the Fraction cut off, thus. If you ſuppoſe the Load to be twenty hundred weight, (which is always accounted to be a Load;) then if the Fraction cut off were 35 parts of a 100: I would know the weight of that Fraction.

Multiply 35 by 20, or double 35, and add a Cypher to it on the right hand, and it will produce 700, which is the value of the Fraction of 35: or let the Fraction be 73, and you deſire the weight; double 73, and it makes a 146, to which annex a Cypher, and it will be 1460, which is the weight of that Fraction.

There might be much more ſaid of Multiplication, as to Mony, in ſeveral Denominations, as pounds, ſhillings, pence and farthings, to be Multipli'd by the like Denominations, or by ſeveral Denominations of Meaſures, either dry, or liquid, or weights great and ſmall. But I ſhall omit them here, and give you ſome account of them, when I come to the Rule of Three.

It will not be out of the way, for a *Gunner* to underſtand how to meaſure *Plank*, or *Board*, or *Timber*, becauſe ſuch things will be for their uſe.

How to Meaſure Plank or Board.

THIS is very Eaſie by Decimals, for you have no more to do then to meaſure the length in feet, and Decimal parts of a foot, and alſo the breadth in the like meaſure, but it often happeneth that the *Plank* or *Board* is broader at the one end then it is at the other: Then you may meaſure both ends, and add them together,

gether, and take the half thereof: then Multiply the length by the breadth, and cut off ſo many figures as you have fractions, and what you have remaining towards the left hand, is feet, and the figures cut off, are fractions of a foot, as will appear by Example.

Suppoſe the length of a *Plank* to be 23 and 53 parts of 100 of a foot, and the wideſt end be 2 foot 72: and at the leaſt end 2 foot 15 parts, which added together, makes 4 foot 87, whoſe half is 2 foot, and 435 parts of a 1000.

Note, here are five fractions, (*viz.*) two in the length, and three in the breadth.

Set them down as before directed, and as is here expreſſed in this Example.

Which being Multipli'd as you are before taught, and the laſt five figures cut off to the right hand; the Anſwer will be 57 foot, and a little above a quarter, for there is no need of clearing the fraction any further.

2:435: *Breadth*
23:53: *Length*
7305.
12175.
7305.
4870.
57.295 55.

But it will be needful to give another Example of a Board, or Plank, that is leſs then one Foot broad, and of an equal bredth.

Example.

There is a Board, which at the broadeſt end is 87 parts of 100 of a Foot, and at the narroweſt end, 73 parts, which added together, make 1 : 60, the half of it is 80 parts of a Foot, and take the length to be 11 Foot and 74 parts, then ſet them down as in this Example.

11: 74
80
9: 3920

Then Multiply them, and cut off four Figures to the right hand for the four Fractions, and the Content will be 9 Foot, and ſomthing more then one third of a Foot.

And by this Manner of Working, you may Meaſure all manner of Flats, as Plank, Board, Glaſs, or any other thing that is to be Meaſured by the foot, and never have occaſion for any Diviſion.

How to Meaſure Square-Timber.

THere is very little Timber that is truly ſquare, but if you meet with any ſuch, Multiply the Side of the Square by the ſame Number, then Multiply the Product by the length

length of the Piece of Timber, and the ſecond Product is the Content of the Piece, in Foot-Meaſure, and every 50 Foot is accounted one Load at *London*, as will appear more plain by this Example.

The Side of the Square, is 95 parts of 100 of a foot, which Multiplied in it ſelf, produceth 9025, as you ſee in the Example.

Which is 9025 parts of 10000: then let the length be 33 foot, and 54 parts of a foot; by which you muſt Multiply 9025, which was the Product of 95 and 95 at the Top.

```
  95
  95
 475
855
9025
```

Now Multiply 9025 by the length 33:54, as you here ſee, then cut off ſix Figures for the ſix Fractions, and the product will be 30 foot, and a little more than a quarter of a foot.

```
  9025
 33:54
 36100
 45125
 27075
 27075
30:269850
```

How

How Timber unequally Squared, and Taper-wiſe, may be Meaſured.

FIrſt, Multiply the broadeſt Square or Side, by the leſſer Side, at the biggeſt end of the piece, and reſerve that Sum, and alſo do the like by the leſſer end of the piece, and add both the products together, and take the half of them, when added, and that half Multiplied by the length of the piece, is very near the Content in feet, and Decimal parts of a foot.

Suppoſe a piece of Timber, that one ſide of the biggeſt end be 1 foot, and 8 tenths of a foot, and the other ſide be 8 tenths.

Firſt, multiply 1:8: by 8: and the product will be 144, then let it be at the broadeſt ſide of the leſſer end, 1 foot and 2 tenths, and at the other ſide, 5 tenths; Then Multiply 1:2:by 5, and the product will be 60.

Then add 144 and 60 together, and it makes 204, the half thereof is 102.

Then ſuppoſe the length of the piece to be 30foot, then multiply 102 by 30, and the product

A Table of Engliſh Coyn in Decimals.

Shillings	Decimals	Far-things	Decimals	Far-things	Decimals
		1	00104167	1	02604167
		2	00208333	2	02708333
		3	00312 5	3	02812 5
		4	00416667	7	02916667
01	05	1	00520833	1	03020833
02	10	2	00625	2	03125
03	15	3	00729167	3	03229167
04	20	2	00833333	8	03333333
05	25	1	00937500	1	038375
06	30	2	01041667	2	03541667
07	35	3	01145833	3	03645833
08	40	3	0125	9	0375
09	45	1	01354167	1	03854167
10	50	2	01458333	2	03958333
11	55	3	015625	3	040625
12	60	4	01666667	10	04166667
13	65	1	01770834	1	04270833
14	70	2	01875	2	04375
15	75	3	01979167	3	04479167
16	80	5	02083333	11	04583333
17	85	1	021875	1	046875
18	90	2	02291667	2	04791667
19	95	3	02395833	3	04895833
20	100	6	025	12	05

Place this page 26. to lie turned out.

duct is the Content of the piece in feet.

Example.

When you have cut off the two laſt figures for the two fractions, it will be 30 foot and 6 tenths, as in the Example.

102
30
30:60

But if this piece were meaſured exactly, as if it were a *Fruſtum*, or bottom of a Pyramid, it will be 31 foot and 2 tenths.

But ſuch a piece cannot be meaſured without the Rule of Three this way, but the other is as true as *Gunters* Line can do it.

The Explanation of the Decimal Table.

THE firſt Column to the left hand is ſhillings, from one to twenty: the ſecond is the Decimals anſwering to the ſhillings: the third and fifth Columns are pence and farthings, begining at 1,2,3, and then 1. The firſt three figures under farthings, are farthings, and the fourth, which is 1, is a peny, and ſo proceeding, every fourth is pence.

The fourth and ſixth Column, are the Decimals anſwering to the pence and farthings.

How

How you may Multiply any Number of Pounds, Shillings, Pence and Farthings, by any other of the like Denomination.

Example.

IF 23 pounds, 13 ſhillings, 7 pence, 2 farthings, were to be multiply'd by 12 pounds, 11 ſhillings, 5 pence, 1 farthing: You muſt firſt look for the Decimal Numbers anſwering thereto, in the foregoing Table, anſwering to the ſhillings, pence and farthings, for the pounds are always proper Numbers of themſelves.

Firſt, look for 13, in the firſt Column to the left hand, and right againſt it, to the right hand, in the ſecond Column, you may finde 65, which is the Decimal anſwering to 13 ſhillings.

Then look for 7 pence two farthings, in the fifth Column (the pence are all Incloſed with lines, and the farthings in this Order, 1, 2, 3, downward) the Decimal anſwering to 7 pence two farthings, you may finde in the laſt Co-

lumn,

lumn, to be 03125, which is to be ſet down as in the Example, and the Decimal of 13 ſhillings under it, to the left hand, then add them together, and the ſum will be 68125:

03125
65
68125

Then place before it towards the left hand, 23, with a Note of Diſtinction, to ſeparate the pounds from the other five figures, which are but a fraction of a pound, and muſt be taken notice of, for look how many fractions there are, ſo many figures muſt be cut off at laſt.

23:68125

Then you may finde by the Table, that the Decimal of 11 ſhillings, is 55, and the Decimal of 5 pence farthing, is 021875, which muſt be ſet down, as in this Example; with the 12 pounds to the left hand, marked or pricked off from the other ſix figures, which are alſo a fraction of a pound.

021875
55
12:571875

Then when the two Sums are Multiply'd together, there will be eleven figures or places, to be cut off to the right hand.

It makes no matter if one Sum have a fraction of two or three places more then the other, or the other none at all; if you but take care how many fractions there are, as will be more plain in this Multiplication, which followeth in this Example. Which

Which is 297 pounds 14ſhiillings and 4 pence, and a little above half of a farthing.

I had thoughts not to have concerned my ſelf with Coyn, but that I was deſired by friends.

But I thought good to ſhew you, how to clear the Fractions of Coyn.

```
12:571875
23:68125
---------
62859375
2514375O
125718 75
100575060
75431250
3771562 5
25143750
---------
297:7177148 4375
```

The firſt three Figures towards the left hand are pounds; And the eleven Figures cut off are the Decimal Fractions of a pound; And always the firſt Figure of the Fraction is double its Number, which here is ſhillings, as here the firſt Figure is 7, which is 14 ſhillings.

But the moſt certain way is to multiply the Fractions by 20, (which is the Number of ſhillings in one pound) and cut off eleven Figures Then again Multiply the Figures, cut off by 12, (which is the Number of Pence in one ſhilling) and cut off eleven places more; And afterwards Multiply the eleven places by 4, (the Number of farthings in one penny;) And cut off eleven places more, and then is the Fraction cleared to the neareſt farthing, as you may plainly ſee by this following Example.

The

The firſt fraction Multipli'd by 20, produceth 14 ſhillings, and the ſecond fraction Multipli'd by 12, yieldeth 4 pence, and the next being Multipli'd by 4, produceth one farthing; and after this manner you may clear any Decimal Fraction of *Engliſh* Mony.

```
7177148437 5.
                20.
14:35429687500
                12.
 708593750 00
 354296875 00
4:25156250000.
                4.
1:00625000000.
```

How to Multiply pounds, ſhillings, pence and farthings, by ſhillings, pence and farthings.

I would have 3 pounds, three ſhillings, and 3 pence 3 farthings: to be Multiply'd by 2 ſhillings, 9 pence, 3 farthings: I take them out of the former Table, as is before directed, and ſet them down as in this Example.

You

You ſee in this Example, that there are ſix Places of Fractions in the *Multiplicand*, and as many in the *Multiplier*; and when there is 12 figures cut off, there will be no pounds at all; then Multiply by 20, as before directed, and there will be cut off 8 ſhillings, and the remainder Multiply'd by 12, produceth 10 pence, and the laſt remainder Multiply'd by 4, yieldeth three farthings, and about one third part of one farthing, ſo the whole ſum will ſtand thus,

3:165625 *Multiplicand*
0:140625 *Multiplyer.*

15828 125
6331250
18993750
126625000
3 165625
445166015625

li. s. d. qu.
00--08--10--03⅓.

Let it be required to Multiply fifteen ſhillings, three pence, three farthings, by 11 ſhillings and 9 pence, take the Numbers Anſwering out of the Table, and ſet them down thus.

The Decimal of 15 ſhillings, 3d. 3 qu. is 765625
The Decimal of 11 ſhillings and 9 pence is 5875
and add two Ciphers, if you will, to make them equal; but there is no need of them, for if they be put on, there will be twelve Places or Figures to be cut off, and without them there will

will be but ten places, which being Multiplied as the other Sums before-going, will ſtand thus 4498046875.

Ten Places being cut off it will not be a Pound; And to finde how many ſhillings, you muſt multiply by 20, the Number of ſhillings in one pound; and cut off the laſt ten Places, and then the Work will ſtand thus: 8:99609 37500: And the Number of ſhillings is eight.

Then multiply the Number cut off by 12, and the Work will ſtand thus: 11:9531250000, when the ten Places are cut off, there will remain to the left hand eleven pence.

Then multiply the ten Figures remaining by 4, (the Number of farthings in one penny, and the Product will be 3:8125000000.

So that eight ſhillings, eleven pence, three farthings, and ſomthing above three quarters of a farthing is the Product of that Multiplication.

Here Note, that any Fraction of a Foot, Yard, Pace, or of a Pound, though never ſo large, can never be the quantity of a Foot, Yard, Pace, or a pound, as hath appeared by theſe Fractions of a pound; And alſo at the beginning of Multiplication in Board or Plank-meaſure.

For if 19 ſhillings 11 pence be to be multiplied

by the ſame Number of 19 ſhillings and 11 pence, it muſt be leſs then one pound, as will appear by the Work following.

The Decimal anſwering to 19 ſhillings and 11 pence, I finde in the former Table, to be 99583333; which muſt be multiplied by the ſame Number of 99583333, and the product will be 9916840211388889.

Here I have eight Fractions in each Number, which makes ſixteen in the whole; and when ſixteen is cut off, there will remain nothing for the pound place.

Then multiply the 16 Figures by 20, and the product will be 19:8336804227779800: when 16 places are cut off, there will remain 19 towards the right hand, which are ſhillings, and the ſixteen that are cut off, being multiplied by 12, the product will be 10:c04165073357360, and ſixteen places muſt be cut off again, as you here ſee, and there will remain to the right hand 10, which is 10 pence.

Then again, if the ſixteen figures which were cut off, be multiplied by 4 (the Number of farthings in one penny) it will not be a farthing.

So the Multiplication of 19 ſhillings and 11 pence, by 19 ſhillings and 11 pence, makes but 19 ſhilling 10 pence, which is leſs then either of the Sums propoſed. I hope

I hope theſe Rules and Examples will be ſufficient for the Menſuration of Board, Plank or Timber, and the Multiplication of *Engliſh* Goyn. It would be neceſſary to reduce ſeveral Weights, Meaſures and Dozens into Decimals; Alſo Moneths, Days, Houres and Minutes into the Decimal parts of a Year, that any Number of Moneths, Days, Houres, Minutes and Seconds, may be multiplied as occaſion ſerveth, and twenty four houres may be divided Decimally, and ſixty minutes divided Decimally, which will be very uſeful.

But for to trouble my ſelf with all theſe, is too much for my intended purpoſe, which was from the firſt, to write ſome ſmall book, to be a Help to ſome of His *Majeſties Gunners*, which underſtand but little of *Decimal Arithmetick*.

Diviſion in Decimals.

Decimals are a very great help in *Diviſion*, where the *Dividend* is leſs then the *Diviſor*, for you may add as many Cyphers as you pleaſe to the *Dividend* (or Sum to be divided,) and the Quotient will be a Decimal Fraction, which may be eaſily cleared, and brought into other Denominations in Menſuration, as Inches

and eight parts; Or in Coyn it may be brought into ſhillings, pence or farthings.

It will not be convenient for you to learn Diviſion before you are very perfect in Multiplication, and to have the Table at the beginning of Multiplication very perfect in your minde.

There may ſeveral Variations happen in Diviſion; The firſt is, to divide a whole Number by a whole Number, that is leſs then the ſum it is to be divided by.

The ſecond is, to divide a whole Number by a whole Number, which is greater then the Number that is to be divided.

The third is to divide a whole Number, and a Decimal Fraction belonging to it, by a whole Number and a Decimal fraction joyned to it.

The fourth is, to divide a whole Number by a whole Number and a Fraction.

The fifth is, to divide a fraction by another fraction that is leſs.

The ſixth is, to divide a fraction by another fraction that is greater.

How

How to divide a whole Number by a whole Number.

AS Multiplication is a doubling or adding of any ſum ſeveral times, whereby the ſum becometh ſo many times the greater: ſo Diviſion is an Abating or Subſtracting of any Figure or Sum, ſuch a Number of times out of a greater Sum, which will cauſe it to become ſo many times the leſs.

Any ſum being to be divided by 2, is but to take the half of the ſum; As if 40 were to be divided by 2, ſay the half of 4 is 2, unto which add a Cipher, and the Quotient is 20.

Any Number being to be divided by 10, if you cut off the laſt Figure or Cipher, the work is done, and the Figures to the left hand are the whole Numbers of the Quotient, and if there be a Figure cut off, it is ſo many tenths, as if 325 were to be divided by 10, cut off the laſt Figure which is 5, and the Quotient will be 32, and 5 tenths, which is 32 and an half; If the 325 were pence, to be divided amongſt ten old Women, every ones part is 32 pence and a half-penny, or two ſhillings eight pence half-penny.

Any ſum that is to be Divided by 20, you may cut off the laſt Figure or Cipher, and take the half of the Remainder, and that half is pounds, and what was cut off is ſhillings. If the laſt Figure were 0 : or 2 : or 4 : or 6 : or an 8. But if the laſt Figure that you are to take the half of, be a 1 : 3 : 5 : 7 : or a 9 : then the Figure cut off will always have a ten to be joyned with it.

As if 5678 were to be Divided by 20, cut off the laſt Figure which is 8, and there will remain 567.

Then ſay the half of 5 is 2, and carry 1, and add it to the next 6, and then ſay, the half of 16 is 8, and then the half of 7 is 3, and carry 1 to the 8, which being placed on the left hand, the 8 will make 18.

So the Diviſion is finiſhed, and will ſtand thus 283 pounds and 18 ſhillings : And this is a very ready way to turn ſhillings into pounds.

Any thing that is to be Divided by 100, is no more than to cut off the two laſt Figures or Ciphers and what remains is the whole Number of the Quotient, and thoſe two Figures being ſo cut off are ſo many parts of an hundred : As if 356894, were to be divided by 100, cut off the two laſt, which is 94, and the Quotient will be 3568, and 94 parts of 100, which want-

eth

eth but six of being 100, then the Quotient would have been 3569.

Suppose 245 shillings, to be divided betwixt seven men; what is each mans part proportionable? set the Number down as in the Example.

Dividend.

In the first place I must enquire how many times 7 I can have in 24, for I cannot have 7 at all in the first Figure, which is 2, so I make a little mark over 4, and take 3 times 7 which is 21, and will be had in 24; and therefore I put a 3 in the Quotient, and set 21 under 24, and draw a line, and say 1 from 4, and there remains 3; and if I should go to the next Figure 2, where there is a 2 over it, and say 2 from 2 and there remains nothing, which being a Cipher, and set on the right hand, would signifie nothing, and therefore is omitted.

divisor 7)245(35 *Quotient*
21
35
35
00 *Remainder.*

Then put a mark or tittle over 5, and bring it down, and set it on the right hand of 3, which will then be 35: then say how many times 7 can I have in 35, which I find to be 5 times, for 5 times 7 is 35, then I put 5 in the Quotient, and 35 under the 35, and substract it, and there remains nothing: so that 35 shillings will be each mans part.

Diviſion by two Figures.

THere is 78568 pounds to be divided equally between 45 men: ſet the figures down.

Thus, Dividend Quotient
Diviſor 45) 78568 (

Making a Comma betwixt the Diviſion which is 45, and the Dividend which is 78568, and likewiſe a Comma to place the Quotient in, as you ſee in the Example.

Then ask how often you can have 4 in 7, which is but once, then ſet one in the Quotient, and ſay once 5 is 5 and ſet it under 8, and once 4 is 4 which muſt be ſet under 7; then ſubſtract this 45 from the 78 which is over it, and there will remain 33; then ſet a mark over the next figure to 8, which is 5, and bring it down and ſet it on the right hand of 33, then

45) 78568 (1745.
45.
335.
315.
206.
180.
268.
225.
43 *Remainder.*

then it will be 335, as in the Example.

Then again, ſay how many times 4 in 33? I can have eight times, but it will not go ſo many times, for I cannot have eight times 5 in fifteen, for when eight times 4 which is 32, is taken out of 335, there will remain but 15, ſo I muſt take but 7 times, and put 7 in the Quotient, and Multiply 45 by 7; ſaying 7 times 5 is 35, ſet 5 under 5, and carry the 3, and ſay 7 times 4 is 28, and 3 I carry'd is 31, which I ſet down behind the 5, then they will ſtand thus 315, this ſubſtracted from 335, there remains 20, then put a mark over the next figure of the Dividend, which is 6, which take down and ſet on the right hand of 20, and they will ſtand thus, 206.

Then ſay how often can I have 4 in 20, which is five times, but I cannot have five times five in the remaining figures, which is a 6; therfore I muſt take but four times, and place that in the Quotient, and Multiply 45 by four, as you muſt always, what figure ſoever you put into the Quotient, by the ſame figure you muſt Multiply the Deviſor, and ſet that product under the figures that you are then dividing.

As here four times 45 is 180, which you muſt ſet under 206, and ſubſtract 180 from 206, and there remains 26, if this 26 had been 45 or more, then there would have been an error

error commited; for then the four in the Quotient muſt have been a five.

And this obſerve in any Diviſion, after ſubſtraction is made upon any number puting in the Quotient, if there remains a greater number than the Diviſor, the figure put in the Quotient ſhould have been greater.

And alſo, when you come to make ſubſtraction, and the number be too big to be had in the uppermoſt figures, then the number put, or intended for the Quotient, is too great.

Therefore it will be convenient until you are very perfect in Diviſion, to make trial upon ſome waſte Papers, how many times it will be had.

Again, to the twenty ſix bring down the eight, and place at the right hand of twenty ſix, and they will ſtand thus, 268.

Then inquire how many times 45 will be had in 268, it will be found to be five times: then 45 being Multipli'd by five, the product is 225, which being ſubſtracted out of 268, the remainder is fourty three, the five being firſt placed in the Quotient, then the Quotient will ſtand thus, (1745, and 43 parts of 45, which may be brought into a Decimal Fraction, by adding of Cyphers as you have occaſion, as by this Example.

When

45)430(

When there is a Cypher added to the 43. it will then ſtand thus, 430.

Then, how many times four can I have in four? I can have it once, bnt then I cannot have once five in the next figure 3: Therefore I ask how many times 45 in 430? anſwer, 9 times; then I Multiply 45, by 9, and ſet it under the Dividend, thus 9 times 5 is 45, ſet down 5 under the Cypher and carry 4.

Then ſay 4 times 9 is 36, and 4 that was carried is 40, place 0 under the 3, and 4 under the 4, then ſubſtract 405, from 430, and the remainder is 25, unto which you may add another Cypher, as you ſee in the Example, and divide again by 45, and that you may have 5 times, then put five in the Quotient behind the 9, and they will ſtand thus, 95.

45)480(95.
405.
250.
225.
25

Then five times five is 25, put 5 under 0, and carry 2, then ſay five times 4 is 20, and 2 carried is 22, which put under the 25, and ſubſtract as before, and the remainder will be 25 again; and if you add more Cyphers, the figures of the Quotient will ſtill continue to be more fives, and the remainder will likewiſe continue to be 25; but you may add as many Cyphers

Cyphers as you will to make the Fraction the larger, as you may ſee occaſion.

Here you may ſee, if 78568 be divided by 45, the Quotient will be 1745: 95 Parts of a 100, or if you add another figure in the Fraction, then it will be 955 parts of a 1000. How theſe Fractions are to be cleared is already ſhewed in the Multiplication.

How to make Decimal Tables for Foot-Meaſure, Yard-Meaſure, or Engliſh *Coyn.*

THeſe are inſerted in the Multiplication before going, but the way of making them is omited there, becauſe they are made by Diviſion.

The firſt is a Table of Foot-Meaſure, where a Foot is divided into ten thouſand Parts, with the Decimal Fraction anſwering to each Inch: And by reaſon that moſt of the Inches will not ex-

exactly anſwer to a proper Decimal Fraction; I begin it thus.

The half of 10000 is 5000, which anſwereth to ſix Inches, then take the half of 5000 and it is 2500, which anſwereth to three Inches: Then if you divide 2500 by 3, the Quotient will be 0833, which is the Decimal Fraction of one Inch, and that Multipli'd by two, produceth 1666, which is the Decimal of two Inches; then Multiply 0833 by 3, and it makes 2500 with adding of one to the laſt place: And then by a continual Addition of 0833, you may have all the Decimals to each Inch with the adding of 1 to the laſt place at ſix Inches, nine Inches and twelve Inches.

Then the finding of the Decimals of each Eighth part of an Inch, is by dividing 0833 by 8, and the Quotient will be 0104, which is the Decimal of one eighth part of an Inch, which being Multipli'd by two, produceth 0208, the Decimal of two eighths of an Inch, to which add 0104, it will make 0312, for the Decimal of three Eighths; and ſo by Addition you may have the Decimal belonging to each his Eighth part, as you may ſee in the Table before going.

The next is a Table, ſhewing the Decimal Fraction belonging to each Nail of a Yard, which be 16.

To make this Table there is no more then

to divide 10000 by 16, and the Quotient will be 0625, which is the Decimal Fraction of one Nail of a Yard.

Then if you Multiply 0625 by 2, the Product will be 1250, which is the Decimal of two Nails: then ſtill adding of the firſt, you will compleat the Table, as is before inſerted.

The making of the Table for the turning of Engliſh Coyn into the Decimal Fractions of a pound, is alſo done by Diviſion: Firſt, divide one hundred into twenty equal parts, and the Quotient is 05, which is the Decimal of one ſhilling, and this doubled, is the Decimal of two ſhillings, which is one tenth part of a pound; and ſo by adding of 05, you may have the Decimal of each ſhilling.

Then to gain the Decimal of the pence, you may do as in the Inches; firſt take the half of 05, which adding as many Cyphers as you pleaſe, which is 025, and their period. And this is the Decimal of ſix pence, or the fortieth part of a pound.

Then take the half of 025, which will period at 0125, and this is the Decimal of three pence, or the eightieth part of a pound.

Then if you divide 0125 with Cyphers added to it by 3, the Quotient will be 00416667, the Decimal of one penny: the double

double thereof is 00833333, which helping the laſt figure as before directed. And by Addition you may have the Decimal of each penny in the ſhilling.

The Decimal of one penny being 00416667, this being divided by 4, the Quotient will be 00104167, the Decimal Fraction anſwering to one farthing, and by this Method may be made ſuch a Table as is before in the Multiplication.

For the turning of Inches and Eighths into the Decimal parts of a Foot: And the Nails of a Yard or Ell, into the Decimal parts of a Yard or Ell.

And for thoſe that have occaſion for any other ſort of Tables for meaſuring, as Pole or Rod, Mr. *Gunter's* Chain, or any other ſort of Chain, what any one may fancy, may by the ſame way, be put into Decimals by the former Rules.

And alſo all ſorts of Weights, great or ſmall, and liquid Meaſures, for Wine, Oyl or Spirits, the Denominator being a Tunn: or for Beer or Ale, the Denominator being a Barrel of 36 Gallons for Beer, and 32 Gallons for Ale, and the Tunn being 252 Wine Gallons or 4 Hogs-heads, every Hogs-head 63 Gallons. As thus,

One

One Rod or Pole, or in ſome places called a Pearch, is by our Statute-law ſixteen Foot and a half in length, which is 198 common Inches, of twelve Inches in one Foot: And 165 inches of ten inches in one Foot, which are called Decimals or Tenths of a Foot.

Then ſuppoſe a Chain of one Pole long, to be divided into an hundred Links; Divide 198 inches by 100, and the Quotient is 1 and 98 parts of 100 of an inch, which you may take off from a Diagonal Scale; but if you divide the tenth of a Foot, one Link will be one tenth of a Foot, and ſix tenth parts of a Decimal inch and an half, which will ſtand thus: 1 : 65 : *viz.* one tenth of a foot, and 65 parts of another tenth.

Mr. *Gunter*'s Chain is four Pole long, and is divided into an hundred Links; what is the length of one Link? one Pole being ſixteen foot and a half, four Pole will make 66 Foot, which is the true length of the Chain in Foot-meaſure; And 66 Foot multiplied by 12, (the common Inches in one Foot) produceth 792 Inches, which being divided by 100, the Quotient is 7 Inches, and 92 parts of a 100, and this 92 multiplied by 8, (the common parts that the Inch is divided into) the product will be ſeven Eighths and 36 parts, which is little more then one third part of an eighth of an Inch.

But

But if you would have the length of one of the ſame Links in the Decimals of a Foot, there needeth no more then to add a Cipher to 66, and it will ſtand thus 660, then divide by 100, which is no more, then to cut off the two laſt places to the right hand, and there will remain to the left hand 6, which is ſix tenths of a foot, and the 60 which is cut off is the 60th. part of a Decimal Inch.

As for the Table of the ſeveral Weights you may have in Mr. *Wingate*'s Arithmetick, and others, for making of a Decimal Table for Wine or Spirits. Divide 1000 or 10000, or more, into 252 parts, which is the Number of Gallons in the Tun, and the Quotient is the Decimal anſwering to one Gallon, and that Decimal divided by 8, will be the Decimal of one Pint, and the Decimal of one Pint divided by 4, the Quotient will be the Decimal of one quarter of a Pint, or thus:

Divide 100000 by 4, and the Quotient is the Decimal of one Hogſhead, (*viz.*) 25000, and this divided by 63 (the Gallons in one Hogſhead) is the Decimal of one Gallon, as before.

Then if to 25 you add ſeven Ciphers, it will ſtand thus, 250000000, and divide that by 63, the Quotient will be 03968254, which is the Decimal anſwering to one Gallon; And,

03968254 divided by 8, is the Decimal of one Pint, (*viz.*) 00496032, and this again divided by 4, the Quotient will be 00124008, which is the Decimal anſwering to one quarter of a pint.

The ſame may be done for Beer or Ale, making the Barrel the *Integer*: A Beer Barrel contains 36 Gallons, and the Ale Barrel 32 Gallons.

Now having ſhewed you the way of making ſome Decimal Tables, I ſhall proceed to a little more Diviſion, which is the *Six Variations* before Treated of.

Example on the firſt Variation.

Nevertheleſs I have done ſomething of Diviſion already, I will give one Example of each Variation as they come in courſe,

EXAMPLE I.

The Number to be Divided, ſuppoſe 75678 pounds, betwixt 457 men, ſet them down as you may ſee here following; then you will find that the firſt Figure of the Quotient will be but 1: therefore place 457 under 756, the three firſt Figures of the Dividend, and ſubſtract 457 from 756, and the remainder is 299.

Then

Then bring down the fourth Figure of the Dividend, and place it at the right hand of 299 then they will ſtand thus: 2997.

Then enquire how often 457 will be had in 2997, and I finde it will go 6 times, then place 6 in the Quotient, and Multiply the Diviſor 457 by 6, and ſet the product under 2997; which is 2742, then ſubſtract 2742 from 2997, and the remainder is 255.

Then make a little Mark under the 8, and bring it down as you did the 7, and then the Number to be divided, will be 2558.

457)75678)165:597

457

2997

2742

2558

2285

273

Then enquire how often 457, will be had in it? I find it will be five times, then I put 5 in the Quotient and Multiply 457 by 5, and it produceth 2285, which being ſubſtracted 2558, there remains 273, which is above half the Diviſor 457.

So each man will have to his Part 165 pound, and a part of the remainder 273, which may be brought into ſhillings two ways, either by adding of Ciphers, or multiplying by 20, and then divide again by the ſame Diviſor, as thus you may clear it by adding of Ciphers.

Then ſee how oft you can have 457 in 2730, which may be had five times.

Then make a Note of diſtinction, that you may know the pounds from the Fractions, as you ſee in the Quotient.

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457)2730(5:97
2285
-----
4450
4113
-----
3370
3199
-----
171
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And ſo you may continue adding of a Cipher, whileſt you have a Fraction of as many Figures as you pleaſe, as you ſee is done in the Example, in continuing of the Fraction to three places, which is 597, and the Remainder is 171, to which may be added another Cipher at pleaſure.

The Clearing of this is ſhewed in the Multiplication, how it may be brought into ſhillings, pence and farthings.

The other way of Clearing is thus: 273 multiplied by 20 is 5460, which being divided by 457, the Quotient is 11, which is eleven ſhillings, and the remainder is 433, which being multiplied by 12, the product is 5196, and this again divided by 457, the Quotient is 11, which is eleven pence, and the remainder is 169, which being multiplied by 4, produceth 676, which being divided by 457, the Quotient is 1, which is one farthing, and the remainder is 219, which you

you may Multiply by 6, and the Product is 1314, this again divided 457, the Quotient is 2, which is two Mites, and the remainder is 38 parts of a 100 of a Mite.

But that ſort of Coyn is not at all uſed, as I know of, therefore it makes no matter to trouble your ſelf with it.

So every ones part will be 165 pounds 11 ſhillings: 11 pence, and one farthing, and two mites, and the 38 part of a hundred of a mite.

I have been the larger in explaining of this, that I may paſs over the reſt, without being ſo tedious to the Reader in the other Examples following.

I think it will not be amiſs, to ſecond this Example with another, that may fall in the ſame Variation, but found like the Rule of Three, or Rule of Practice.

If 7840 pounds of Gunpowder, (which is 70 hundred, at 112 pound to the hundred weight) coſt 322 pounds, how much will one pound coſt?

This is done by Diviſion, by adding as many Cyphers as you pleaſe to 322 pounds, and then divide it by the number of pounds of Powder, and the Quotient will be the Decimal Fraction of twenty ſhillings, which being cleared will give you the value of one pound of Powder,

Thus divide 322 : 00000000, with the eight Ciphers added to it, by 7840, and the Quotient will be 4107142, and the remainder will be 6720 parts of 7840 the Diviſor, therefore you may as well make the laſt Figure of the Quotient, which is a 2, to be a 3, and then the Quotient will be 4107143, which is the Decimal anſwering to the price of one pound of powder.

Then to reduce the Decimal into *Engliſh* Coyn, multiply it by 20, and the product is 821428260 : Then cut off as many places as you added Ciphers, and what remains will be pounds in Coyn, but here is none.

Then multiply the laſt product by 12, and it will be 9:85614320, from which cut off eight places to the right hand, and what remains to the left is pence, which in this Example is 9 pence.

Then multiply 85614320, the fraction cut off by 4, which is the farthings in one penny, and it will produce 3:42457280; and eight Figures being cut off again, there will remain 3 to the left hand, which is three farthings, and the remainder is 42457280, which is almoſt half a farthing, or 42457280 parts of 10000,0000 of one farthing.

So the Anſwer of the Queſtion will be for the price of one pound of powder, 9 pence, 3 farthings, and almoſt half of a farthing.

And

And by this Example any thing may be done, either in Weights or Measure, regard being had to each proper Denomination.

How to Resolve this Question without the Help of Decimals.

If 70 hundred Weight cost 322 pounds, how much will one pound cost? First, turn the hundred weights into pounds by multiplying 70 by 112, then the Number of pounds will be 7840.

Then produce the 322 pounds into pence, by Multiplying first by 20, which will bring it into 6440 shillings, and that multiplied by 12 produceth 77280 pence.

Then divide 77280 the Number of pence, by 7840, the Number of the pounds in weight, and the Quotient will be 9, which is nine pence, and the remainder will be 6720, which is less than the Divisor: therefore 9 pence is as many pence as one pound will cost.

Then multiply 6720 by 4, the Number of farthings in one penny, and the product will be 26880, then divide this 26880, by 7840, and the Quotient will be 3, which is three farthings, and the remainder will be 3360 parts of 7840 of a farthing, which is almost half of a farthing, as it was before found by the Decimal way.

If 7 Hogſheads of Tobaccho, weighing 27 hundred, coſt 50 pounds; what is that by the hundred weight?

Put the 50 pounds into ſhillings, and it makes 1000 ſhillings, then divide by 27, and the Quotient will be 37, and one remains, ſo one hundred weight will coſt 37 ſhillings, and a little more then one farthing.

EXAMPLE II.

How to Divide a leſſer Number by a greater?

As thus: 357 pounds is to be divided amongſt 475 men: here the Diviſor is greater then the Dividend, and therefore the Quotient muſt be a Fraction; (therefore add as many Ciphers as you think convenient to the Dividend, and then divide as if it were a whole Number, thus, 357000 to be divided by 475, the Quotient will be as many Figures as you add Ciphers, *viz.* 751578, this Quotient multiplied by 20, produceth 51:031500, cut off ſix Figures, and the 15 remaining are ſhillings: Then multiply 031560 by 12, and the product will be 0377720, and ſix of theſe cut off again, there will remain a Cipher in the room of pence, then multiply that Fraction by 4, and the product will be 1:499880, which is one farthing and almoſt a half.

So

So every Mans part will be 15 ſhillings 0 pence, 1 farthing, and almoſt a half.

This you may alſo work without Decimals, by reducing the 357 pounds into ſhillings, which is 7140. Then divide 7140 by the Number of Men 475, and the Quotient will be 15, and the Remainder 15, which being multiplied by 12 will yield 180, which is leſs then the Diviſor, and therefore affordeth no pence: then multiply 180 by 4, and thereof cometh 720, which is more then one farthing, as before appeared by the Decimal Work.

EXAMPLE III.

How to Divide any Number that is *Greater* than the *Diviſor*, with a Decimal Fraction belonging to the Dividend, and another to the Diviſor?

Here in this caſe, if the two Fractions are not equal in Number of Places, put Ciphers to make them equal: Then, ſo often as the Diviſor is contained in the Dividend, ſo many Figures are whole Numbers in the Quotient; And then to have the Fraction as large as you pleaſe, add Ciphers to the Dividend: And as many as you add, ſo many places will be the Fraction.

And this laſt Rule being well obſerved, will be a certain way to know how many Figures of thoſe

thoſe in the Quotient are whole Numbers, and alſo how many Fractions there are.

If 123 pounds, 13 ſhillings, 3 pence, 3 farthings, were to be divided, (which in Decimals ſtandeth thus: 123:665625 for the Dividend) and admit the Diviſor to be 11 pounds, 17 ſhillings, 4 pence, 2 farthings, (which in Decimals ſtandeth thus 11:86875: here the Fraction of the Diviſor is one place leſs then that of the Dividend: therefore, (as before directed) add a Cipher to 86875, and it will then ſtand thus: 11:868750

Diviſor	*Dividend*	*Quotient*	*Remainder*
11:868750:	123:665625	10:	4978125

Then to this Remainder add as many Ciphers as you pleaſe to have Fractions in the Quotient, and divide by the ſame Diviſor, and add ſix Ciphers.

Diviſor	*Dividend*	*Quotient*
11:868750:)	123:665625000000:	(419515:

and the Remainder is 6343750 parts of 11:868750, which is a little more then a half, and if you will, you may put ſeven Figures or Places in the Quotient, and then the Quotient will be thus 4195155.

Then

Then the Quotient will be 10 pounds, and 4195155 decimal parts of a pound, which if cleared, as before directed, it will be found to be 8 ſhillings, 4 pence, and almoſt 3 farthings.

This may be done without Decimals, by reducing of all the money into farthings: Firſt, multiply all the pounds by 20, and to that product add the Number of ſhillings, then multiply by 12, and to its product add the Number of pence, then multiply that Number by 4, and likewiſe to its product add the farthings belonging to your ſum, and that will give the Number of farthings in any ſum of pounds, ſhillings, pence and farthings.

As in the Queſtion before going, 123 pounds 15 ſhillings 3 pence and three farthings, being reduced as before directed, will be 118719 farthings, to be divided by 11 pounds 17 ſhillings, 4 pence and 2 farthings, which being reduced into farthings, makes 11394 for the Diviſor, then divide 118719 by 11394, and the Quotient will be 10, and the remainder 4779, which Multipli'd by 20, makes 95580, then divide that by 11394 and the ſecond Quotient will be 8 and the remainder 4428, which being Multipli'd by 12, produceth 53136, this divided by the former Diviſor, the third Quotient will be 4, and the remainder 7560, this Multipli'd by 4 gives

gives 30246, which being divided by the ſame Diviſor, the fourth Quotient will be 2, and the remainder 7452 parts of 11394 of a farthing; which agreeth very well with the Decimal Work, and is a very good proof to the Operation thereof.

EXAMPLE IV.

How to divide a whole Number by a whole Number and a Fraction?

Suppoſe the whole Number to be 7582, and this to be divided by 87 : 358 : (here note that 87 is a whole Number, and 358 is a Decimal Fraction) then to divide this, add to the Dividend three Cyphers and it will ſtand thus, 7582000, then divide it by 87 : 358, as if they were both whole Numbers: And thus do always in ſuch Caſes, add as many Cyphers to the Dividend as there are Fractions in the Diviſor, then all the figures in the Quotient will be whole Numbers, ſo far as theſe Cyphers extend.

Then to gain a Fraction to the whole Numbers in the Quotient, add as many Cyphers more as you pleaſe, and as many Cyphers as you add, ſo many places the Fraction will be.

Firſt, I divide 7582000 by 87 : 358, and the Quotient is 86, and the remainder is 69212, to which

which add three Cyphers, and the remainder will ſtand thus 69212000, which being divided by the former Diviſor, the Quotient will be 792 for the Fraction, which being placed in order will ſtand thus 86 : 792 : And if you deſire the Fraction to be more, you may add ſtill more Ciphers to the firſt or ſecond Remainder, and as many Ciphers as you add, ſo many Places the Fraction will be of: the ſecond Remainder is 24464.

EXAMPLE V.

How to divide a Fraction by a Fraction that is leſs?

As if 19 ſhillings 11 pence 1 farthing, were to be Divided by 7 ſhillings 3 pence 3 farthings: Firſt, out of the Table of *Engliſh* Coyn, take out the Decimal anſwering to each, the Decimal of the greater 996875, and the Decimal of the leſs is 365625, then Divide 996875 by 365625, and the Quotient is -2, and the Remainder is 265625; to which if you add ſix Ciphers, and divide that product by the ſame Diviſor, the Quotient will be 72649, and almoſt 6, which is a Decimal Fraction of a ſhilling, and if it be cleared it will be 8 pence, and very near to 3 farthings: ſo the firſt and ſecond Quotient, when cleared, will be 2 ſhillings, 8 pence,

pence, and almoſt three farthings, as will appear if you convert it all into farthings, and then divide the farthings in the greater ſum, which are 957, by the farthings in the leſſer ſum which are 351, then the Quotient will be 2, and the Remainder 255, which multiplied by 12 produceth 3060, which being divided by 351, the Quotient will be 8, and the Remainder 252, which being multiplied by 4, the Quotient will be 2, and the Remainder 306, part of 351 of a farthing, which agreeth very well with the decimal work, and is a very good proof of the truth thereof.

Here Note, that if farthings are divided by farthings, if there be more farthings in the Diviſor then 960, which are the Number of farthings in one pound, or twenty ſhillings, the Quotient will be pounds, as in the third Example.

But if there be not ſo many farthings as 960, then the Quotient will be ſhillings, as in the Example before-going.

And in dividing of farthings by farthings, if the Diviſor be leſs then 48, the Quotient will be a penny or pence.

What hath bin ſaid of farthings, the ſame Rule may be obſerved in half-pence, or pence, for any Diviſor of half-pence, more then 480, or any Diviſor of pence more then 240, the Quo-

Quotient will be pounds, and if leſs then theſe Numbers, the Quotient will be ſhillings, and if leſs then 12 or 24, the Quotient will be pence.

If you divide 753 half-pence by 375, the Quotient is 20 ſhillings, and the Remainder 3 parts of 375, which is about one farthing: And in Decimals thus, the greater Number of farthings is 31 ſhillings and four pence half-penny, the leſſer 15 ſhillings 7 pence half-penny, their Decimal is 1 : 57875, the leſſer 78125, then if you Divide 157875, by 78125, the Quotient will be 20: And the Fraction 0208, which being Multiplied by 12, produceth 2496, which is not any pence, becauſe four Fractions are to be cut off.

EXAMPLE VI.

How to divide a Fraction by another Fraction that is greater then the Dividend?

And to perform this by Decimals, is but adding of Ciphers, to make that which were tens to become hundreds or thouſands; if there were 7 pounds, 5 ſhillings, 9 pence and 3 farthings, to be divided by 17 pounds, 18 ſhillings ſix pence three farthings, the Decimal anſwering to the firſt ſum is 7 : 290625, and the Decimal anſwering to the ſecond ſum, is 17: 928125

which

which is greater then the ſum to be divided, therefore you may as you have been directed, add as many Ciphers as you pleaſe to the former ſumm, add ſix Ciphers, and it will ſtand thus: 7: 29062500000, which being divided by 17: 928125, you muſt conſider, that the firſt figure of the Quotient cannot be pounds, by reaſon 17 pounds cannot be had in 7 pounds, but if 7 pounds be put into ſhillings, it will make 140 ſhillings, and then 17 or 18 may paſs or be had in 140, 7. or 8 times, in ſuch Caſes take care to know of what Denomination the firſt Figure of the Quotient is, and in the dividing of this ſum, or any ſuch like, it will be convenient to make this Enquiry, how often 17 can be had, which is 0 times; then to place a Cipher in the firſt place of the Quotient, which will ſignifie that the Quotient is leſs in va'ue then the Diviſor, and therefore can be but a Fraction or Decimal of a pound, foot, yard, pole or chain, or of what other Denomination ſoever the Diviſor and Dividend may be; it may alſo happen that the Dividend may be ſo ſmall, as that there may be two or three Ciphers in the Quotient, before any Figures take place; but if but one Cipher, then the firſt Figure of the Quotient is tenths; and if two Ciphers, then the firſt Figure is an hundred parts; and if three Ciphers, the firſt is a thouſand part o the

Divi-

Diviſor, &c. as occaſion. Suppoſe 7: 29062.5000000, are to be divided by 17. 928125. The Quotient will be 0400658, and the Remainder 9543750, which you may prove by multiplying 17928125 by 4006658, and to that product adding the Remainder of 9543750, and you will find the ſum to be juſt 7290625000000, which is a ſufficient proof of the Diviſion, and the firſt Figure of the Quotient is four tenths of a pound, which is eight ſhillings, the reſt of the Fraction you may clear, as before directed. The ſame may be done if you leave off the pounds, and take the two Fractions, as thus: Divide 290625 with Ciphers by 928125; Now in this caſe 8 ſhillings cannot be had in 5 ſhillings, but it may be had in 60 pence, or the Decimal anſwering thereunto. Example:

If you divide 290625000000 by 928125, the Quotient will be 0313131, and if you look for this Number in the Decimal Table of Coyn before-going, you may finde it a little more then pence half-penny; or you may multiply by 12, and it will produce 7: 575772, then cut off 5 Figures, and multiply them by 4, and it will prove to be, 2. 30288; Five being again cut off, there will remain 2, which is two farthings, and the five Figures cut off is almoſt one third of a farthing.

This I hope will be ſufficient to be ſaid concerning Diviſion of Decimals, at preſent; though indeed there are ſeveral more Variations then the Six herein before mentioned: But at firſt it was not my intention to put forth a Book of Arithmetick, but only ſome convenient Rules and Examples, for the Aſſiſtance and Direction of my Brethren his Majeſties Gunners, and therefore I preſume my brevity herein may be excuſed, till a kind acceptance of this produce a further opportunity.

Reduction

IS a Rule very eaſie, when you have learned the former, and ſerves to reduce greater ſums into ſmaller denominations, and on the contrary to bring ſmall denominations into greater.

EXAMPLE I.

I would know how many half-pence are in 234 pounds. Firſt, multiply 234 by 20, the Number of ſhillings in one pound, and the product is 4680 ſhillings, then multiply 4680 by 24, the Number of half-pence in one ſhilling, and it produceth 112320, the Number of half-pence in 234 pounds.

EX-

EXAMPLE II.

How many farthings are in 27 pounds, 17 ſhillings, 7 pence, two farthings?

Firſt, reduce the 27 pounds into ſhillings by multiplying it by 20, which makes 540, to which add the 17 ſhillings, then it will be thus, 557, which multiplied by 12, makes 6684, to this you muſt add the 7 pence, and the total will be 6691, which being multiplied by 4, makes 26764, to which add the two farthings, and the whole ſum deſired is 26766.

EXAMPLE III.

To know how many four pence half-pennies are contained in any ſum of money

Reduce the ſum of money into half-pence, and divide the Number of half-pence by 9, which is the Number of half-pence in one four pence half penny, and the Quotient is the Anſwer, and what remains is half-pence.

EXAMPLE IV.

If you would know how many thirteen pence half pennies are in any ſum of money, divide the ſum into half-pence by 27, and the Quotient is your deſire, and the remainder (if any be) are half-pence.

As ſuppoſe 175 pounds, 3 ſhillings, 4 pence half-penny, were to be put into 13 pence half penny; the ſum of money in half pence is 84081, and this divided by 27, the Quotient is 3114, which is ſo many thirteen pence half-pennies, and the remainder is 3, which is 3 half-pence: The ſame may eaſily be done by any other ſum.

EXAMPLE 5.

If you deſire to know how many pounds are in 758758 farthings.

Firſt divide the ſum of farthings by 48, which is the Number of farthings, that make one ſhilling, and the Quotient is 15807 ſhillings, and the Remainder 22, which is 22 farthings or 5 pence half penny, then divide the Number of ſhillings by 20, and the Quotient is 790, which are pounds, and a remainder of 7, which is ſhillings, ſo you ſee this Number of farthings will be, 790 : 07 : 05½.

Note, if any Sum of Half-pence be to be reduced into pounds and ſhillings, in ſtead of dividing by 48, as you did before, you muſt divide by 24, for ſo many half-pence make one ſhilling, and if pence are to be reduced, divide by 12, and the Quotient will be ſhillings, which you may put into pounds as before.

Red

Reduction is very uſeful in ſeveral Weights and Meaſures, which to inſiſt upon will be too tedious for my intended purpoſe, and therefore I ſhall conclude this ſubject with one more.

EXAMPLE 6.

To ſhew you how many Pints are contained in 7 Tun, 2 Hogſheads, and 57 Gallons of Wine:

Four Hogſheads make one Tun, and one Hogſhead is 63 Gallons; therefore firſt put it all into Hogſheads by multiplying 7 by 4, which make 28, to which add the two Hogſhead makes 30 Hogſheads, then multiply 30 by 63, and the product is ——— 1890

57

To which add the 57 Gallons, and the ſum is } 1947.

Then multiply that ſum by 8, the Number of Pints in one Gallon, and the ſum ſought for is 15576.

The Rule of Three Direct.

OBſerve that all the former Rules before-going are but an Introduction to this; and the

well understanding of this, will make you more perfect in those Rules, there being nothing to be done herein, but what is by Multiplication and Division, and it is generally termed the *Golden Rule*, or Rule of Proportion, having three Numbers given to find a fourth, for always what Proportion the first hath to the second, the same is between the third and fourth, or Number sought after; for if the first Number be but half of the second, then the third will be but half of the fourth; and the like will follow in a true Proportion to any other Parts or Numbers, and may be performed several ways; but for brevity sake I shall only (here) make use of the two following.

The first Way

Which is most usual is performed by multiplying the second and third termes together, and dividing that product by the first term, and then the Quotient will be the fourth term, or Proportional Number desired.

The second Way

Is very useful for certain Fixed Numbers, where the first and second Numbers or Terms are always the same, as 7 and 22, and 113

and

355, which is near or the ſame Proportion of the Diameter to the Circumference, although that famous and learned Artiſt *Archimedes*, did allow of 7 and 22 to be the Proportion for finding the Circumference of a Circle, as being the ſmalleſt whole Numbers that will come near the truth. But *Ludov. van Cullen* putteth the Diameter of a Circle to be 1, and 36 Cyphers, and by his Eſſay 113 and 355 are much nearer the truth; and for the *Area* or *Superficial* Content of a Circle, as 14 is to 11, ſo is the ſquare of the Diameter to the *Area*; But by *Van Cullen* and later Authors, it is agreed, that the Proportion following is neareſt the truth, *viz.* as 452 is to 355, ſo is the ſquare of the Diameter to the *Area*; Now theſe being Fixed, and ſtanding Numbers may be very uſeful in this ſecond way of Working the Rule of Three, which is thus, Divide the ſecond term by the firſt term, and that Quotient being multiplied by the third term, will be the fourth, or Proportional Number deſired, as may more plainly appear by Examples.

EXAMPLE I.

The Diameter of a Circle being given to find the Circumference by the Firſt Rule.

The Diameter given is 30 inches, then ſay

as 113 is in proportion to 355, ſo is 30 to a fourth Number; Firſt, multiply 355 by 30, and the product is 10650, which divided by 113, the Quotient is 94, and the Remainder is 28; to which add 2 Cyphers, and it will ſtand thus: 2800, which divided again by 113, and the Quotient will be 24, and this 24 is ſo many parts of 100 of an inch, but if you add 3 Cyphers, the fraction will be 247, and the Circumference of the Circle will be 94 inches, and 247 parts of 1000 of an inch, which will ſtand thus, 94: 247.

Having the Diameter of a Circle, to find the Area, *or Superficial Content.*

Work thus: as 452 is to 355, ſo is the ſquare of the Diameter 30, to the *Area*.

Multiply 30 by 30, and that is the *Square*, (*viz.*) 900, which being multiplied by 355, produceth 319500, then divide this laſt product by 452, and the Quotient will be 706, and a Remainder of 388, to which add three Cyphers, and it will ſtand thus, 388000, which being divided by 452, the Quotient will be 858, ſo the *Area* of the Circle will be 706 inches, and 858 parts of 1000, and will ſtand thus, 706:858.

Having

Having the Diameter of a Circle, to find the Circumference by the ſecond Rule.

Firſt, divide 355 by 113, and the Quotient will be 3, and the Fraction left 16, to which add as many Ciphers as you pleaſe, for ſo many as you add, ſo many places muſt be cut off in the next Multiplication; as here I add four Ciphers, and it ſtands thus 160000, which being divided by 113, the Quotient is 1416, very near; then place the 3 before them, as you ſee, 3 : 1416, and this multipli d by 30, is 94,2480, the Circumference as before: By which you may underſtand, that by this Number you may have the Circumference of any Circle, by Multiplying the Diameter by 3 : 1416, and cutting off four Places to the right hand, what remains to the left hand are whole Numbers, and the reſt a Decimal Fraction.

Having the Diameter of a Circle, to finde the Area *by the ſecond Rule.*

Firſt, divide 355 with 4 Ciphers by 452, and the Quotient will be, 07854 almoſt, then multiply the ſquare of the Diameter, *viz.* 900, and the product is 706 : 8600, which is near to the former; ſo by this Number 7854, if you mul-

Multiply the Square of any Circle, and cut off four Figures to the right hand, what remains to the left, is the Area of the Circle in Inches, or Feet, according to the meaſure the Diameter is meaſured by, and what is cut off, is a Decimal Fraction of a 10000, as in the former Rules.

Having the Circumference of a Circle to find the Diameter by the firſt Rule.

EXAMPLE II.

The Circumferenre given as before it was found 94. 247, then as 355, is to 113, ſo is the Diameter given to the Circumference: therefore Multiply 94: 247, by 113, makes 10649: 911, which divided by 355, the Quotient is the Diameter.

Note, that you are to add 3 Cyphers to 355, and they will ſtand thus, 355000. The reaſon of placing the 3 Cyphers to the Diviſor, is becauſe there are three Fractions in the Dividend, as you may ſee in the Diviſion before going, and when the Diviſion is performed, the Quotient will ſtand thus, 29: 998, and this wants 2 parts of a 1000 of making out the firſt Diameter given,

given, which is ſo ſmall difference that it cannot be diſcerned on the fineſt Scale.

Having the Area of a Circle, to find the Circumference.

As 1, is to four times the former number 3: 1416, this number Multipli'd by 4 produceth 12: 5664, and ſo is the Area to the Square of the Circumference, the Root whereof is the Circumference; the Area before found is 706: 858, which being Multipli'd by 12: 5664, the product will be 8882; 66037 12, and the Square Root thereof very neer to 94: 297 which differeth very little from the Circumference firſt found, by the Diameter in the firſt Example. Yet notwithſtanding this operation of Circles, is very exact and eaſie enough, it may with much more eaſe be performed by the Logarith: at the End of the Book.

Having the Area of a Circle, to find the Diameter.

Suppoſe the Area or ſuperficial Content of a given Circle, to be 706: 858. then ſay, as 355 is to four times 113, which is 452, ſo is the

the Area 706: 858, to a fourth Number, the ſquare Root thereof is the Diameter, Multiply 706: 858, by 452, produceth 319499: 816, and the ſquare Root thereof is neereſt to 30: 060, which is a little more then half a tenth part of an Inch too much.

Having the Circumference of a Circle to find the Area.

The Circumference given is 94: 247, to perform this; ſay, as four times 355, which is 1420, is in proportion to 113, ſo is the ſquare of the Circumference to the Area; ſquare the Diameter (that is) Multiply 94: 247, by the ſame Number, the Product will be 8882: 497009: then Multiply the ſquare of the Diameter by 113, and the Product is 1003722: 162017, then divide this laſt Sum by 1420, and the Quotient will be 706: 846593, and this is ſufficiently neer the firſt Area found.

Having the Diameter of a Globe to find the ſuperficial Content.

As 113 is to 355, ſo is the ſquare of the Diameter, to the Superficial content, Multiply the ſquare of the Diameter by 355 and the Product thereof, divide by 113, and the Quotient is the Superficial content.

Another

Another way.

Square the Diameter, and Multiply that Product by 3: 1416, (the making of which Number you have in the Rule of Working the Rule of Three:) and the Product of that Multiplication (cutting off the four laſt Figures) is your deſire.

Having the Diameter of a Globe or Bullet to find the ſolid Content.

As ſix times 113 (which is 678) is to 355, ſo is the Cube of the Diameter to the ſolid Content.

EXAMPLE III.

Admit it were deſired to know the ſolid Content of a ſhot of eight Inches Diameter; firſt Multiply 8 by 8, makes 64, which is the ſquare of 8; then Multiply 64 by 8, and it will be 512, and this is called the Cube of 8, which being Multipli'd by 355, produceth 181760, which muſt be divided by 678, and the Quotient will be 268: 082; by which you may obſerve that any round ſolid, whoſe Diameter is 8 Inches, will contain 268 Cubical or ſolid Inches, and 082 Parts of a thouſand of an Inch; this is very neceſſary

neceſſary to find how much the hollow or concavity of a Granado-Shell will contain.

Note, by the ſame Rule a Ball of four Inches Diameter will contain 33 Cubical or ſolid Inches, and almoſt 51 parts of an hundred.

Having the Diameter and heighth of a Cylinder, *to find the Superficial Content.*

A *Cylinder* is a round Piece, the Diameter whereof is equal at both ends, and alſo in the middle, like unto a Rule which is commonly uſed in Gardens and bowling-Greens.

To meaſure the Superficial Content of theſe Figures, is no more then to girt them about, or by their Diameter find their Circumference, and Multiply that Circumference by the length, and then, as before directed, find the Area's of both the ends, which added to the former Product, giveth the Superficial content, and the ſolid content is found by Multiplying the length by the Area of one of the ends, and that ſum is the ſolid content in Inches.

But if you would have it in Foot-meaſure, you may divide it by 1728, which is the number of Inches in one Foot: And if it be deſired in Wine-meaſure, then divide it by 231, the Cubical or ſolid Inches in one Wine-gallon, and the

the ſame do for Spirits, ſtrong Waters, and Oyl.

But for Beer or Ale, you are to divide by 282, for ſo many Inches are allowed to be a Gallon of thoſe Liquors.

How to find the ſolid Content of a Butt *or* Pipe, *or any greater or ſmaller* Cask.

By the former directions, find the Area at the Bung and Head, and divide each Area into 3 parts, then take 2 of thoſe parts belonging to the Bung, and one of thoſe parts belonging to the Head, and add them together, and that ſum ſo added, being Multipli'd by the length of the Cask, will be the content of the Cask in Inches, which may be reduced into Gallons of Wine or Beer, as before directed.

EXAMPLE IV.

The dimenſions of a Cask, in Mr. *John Elwicks* Vinegar-Yard, in St. *Giles* in the Fields, were taken the third of *April* 1677. as followeth, (*viz*) the Diameter at the Bung, 64: 5, and at the Head 55: 25, and the length thereof 56 Inches.

Now

Now to find the Content of this Cask in Inches, Gallons, Hogſheads and Tuns: Firſt, ſquare the Diameter at the Bung, which is to multiply 64:5, in it ſelf, which produceth 4160:25, which multiplied by 355, makes 1476888:75, and this Dividend by 452, the Quotient is 3267:45: One third part whereof is 1089:15, which being doubled is 2178:30, which muſt be reſerved until you have gained the *Area* at the Head, and one third thereof; for the Performance of which Square 55:25, the Diameter at the Head, which makes 5052:5625, and that multiplied by 355, produceth 1083659:6875, then divide this laſt Number by 452, and the Quotient is the *Area* or Superficial Content of the Circle or Head of the Cask, which is 2397:47718, and one third of the *Area* is, 799:15906; and this muſt be added to the two Thirds before reſerved, which make in all 2977:45906, and this ſum multiplied by 56 Inches, the length of the Cask, the product will be 166737:70736, and this ſum is the Content of the Cask, in Solid or Cubical Inches: Then you muſt underſtand, that the Wine or Gallon containeth 231 Cubical inches, and the Beer or Ale Gallon containeth 282 Cubical Inches, then divide 166737:70736, by 231, and the Quotient will be 721:80825, which is almoſt 722 Gallons; then divide 722

by

by 63 the Gallons in one Hogſhead, and the Quotient will be 11, and 29 remaining, which ſignifieth 11 Hogſheads and 29 Gallons. Now 4 Hogſheads make a Tun, and therefore this Cask will hold 2 Tun 3 Hogſheads and 29 Gallons, according to the Dimenſions given.

Again, if 166737 : 70736 be divided by 282, the inches in a Gallon, the Quotient will be 591 Gallons, of Beer or Ale, and a little more then a quarter of a Gallon, then divide 59 by 36, to bring it into Barrels of Beer, the Quotient will be 16 Barrels, and the remainder 15 Gallons, and 9 of them make one Firkin, ſo the Cask will hold in Beer, 16 Barrels, one Firkin and 6 Gallons; If you would know how much all this Cask will hold, you may divide 591 by 32, and the Quotient is 18 Barrels, and 15 Remains; Now 8 Gallons of Ale make 1 Firkin, ſo it will hold in Ale, 18 Barrels, 1 Firkin, and 7 Gallons.

How to Meaſure Cones *and their* Fruſtums.

A Cone hath a circular baſe, and at the Top it meeteth in a point after the manner of a round Spire Steeple, the *Fruſtum* of a Cone, is a piece of any length cut off at the bottom, as it may ſignifie a piece of round Taper Timber, ſo much

leſs at the upper end, then at the Baſe or bottom, that if lines be drawn on each ſide thereof, they will touch all along the ſide (if it be ſtreight) and in ſome convenient diſtance beyond the little end meet in a point, or interſect one another.

A round Tunn is alſo a fruſtum of a Cone or any other ſtreight ſided Veſſel, that hath one Diameter bigger then the other, as Charns or Water-Tankerds, or full-Pots, commonly uſed in Victualling-houſes, or any other thing of that Shape.

How to find the Superficial Content of a Cone.

Multiply the heighth of the ſide by half the compaſs of the Baſe, and to that product add the Area of the Baſe, and that Sum will be the Superficial Content, but if the Cone be a ſtanding thing, that the Baſe or bottom is not to be come at, that it can neither be painted or boarded, and therefore no occaſion to meaſure it, and then the Area of the Baſe may be left out.

How to find the Cubical or ſolid Content of the Cone.

Having the Circumference or Diameter given,

given, find the *Area* by the firſt or ſecond Example before going, then having the height or length of the Cone, take one third part thereof, and by that multiply the *Area* of the Baſe, and that product is the ſolid Content in Inches or Feet, according to what the *Area* and length are meaſured by.

EXAMPLE VI.

The Diameter of the Baſe is 30, the *Area* is found to be 706:858; or the Circumference given 94:247, the *Area* is 706:857 almoſt; then take the height or length of the cone, to be 282, which being divided by 3, the Quotient is 94, which is one third of the height, then multiply the *Area* 706:858, or the other (which you pleaſe) by 94, and the product is 66444:652, which is the ſolid content of the Cone, and if you multiply the other *Area*, found by the Circumference, which is 706:857 by 94, the product will be 66444;648, which differs only 4 parts of 1000, which is of no value conſiderable.

Having the length of the Cone, and Diameter of the Baſe, to find the Diameter of any Part of the Height or Length.

As the length of the Cone is to the Diameter of its Baſe; ſo is any part of the length to the Diameter anſwering thereunto.

Suppoſe the length of the Cone to be 282, (as be ore) and it be deſired to know the Diameter, at 48 Inches from the Baſe; ſubſtract 48 from 282, and the remainder is 234; then your Queſtion will be thus; as 282 is to the Diameter of the B ſe 30, ſo is 234 the ſecond length given, to 24: 893, the Diameter at 48 In hes from the Baſe, for if you Multiply 234 by 30, the Product will be 7020; which being divided by 282, the Quotient is 24: 893.

Having the length of the Cone, and the Circumference of the Baſe; to find the Circumference at any diſtance from the top of the Cone.

As 282, the length is to 94: 247, the Circumferenc e ſo is 234, the other length to 78:20, the Circum erence.

Having the length and Area of the Baſe, to find the Area at any other diſtance from the top.

As 282, the length is to 706: 858, the Area of the Baſe; ſo is 234 the difference from the top to 586. 54, the Area at the diſtance; and theſe proportions will hold in greater or higher Cones.

Having

Having the length of a Cone, and the Diameter, Circumference or Area given at any diſtance from the Vertex; to find the Diameter Circumference or Area of the Baſe.

As the length of part of the Cone, given from the Vertex, is to the Diameter, Circumference or Area, ſo is the whole length of the Cone to the Diameter, Circumference or Area of the Baſe.

This is but the Converſ Rule of the former, and by ſome called the backer Rule of Three; but I ſhall here put it in the direct Rule; for as part of the length given, is to the Diameter, Circumference or Area, ſo is the whole length of the Cone to the Diameter, Circumference or Area of the Baſe of the whole Cone: Becauſe as part of the length 234, is to the Diameter at that diſtance, ſo is the whole length of the Cone 282, to the Diameter of the Baſe 30.

And as the ſame 234 is to 78: 20, the Circumference, ſo is the whole length of the Cone, 282, to the circumference of the Baſe 94: 247.

And alſo as the former 234, is to 586: 54, the Area at that diſtance from the Vertex, ſo is the whole length of the Cone to the Area at the Baſe 706: 858.

Having both the Diameters, and the depth of ſuch *Fruſtum* given, to find the length of the Cone.

As the difference between the leſſer and greater Diameter is to the depth, ſo is the greater Diameter to the length of the Cone.

If a Piece of Taper-round Timber, whoſe greater Diameter is 30 inches, which in Decimals of a Foot will ſtand thus, 2:5, ſignifying 2 Foot and a half, and in length 150 inches, which is 12 foot and a half, and will ſtand thus, 12:5, the Diameter at the leſſer end is 13 inches and 475 parts: you may put what remains above 12 inches, into Decimals of a Foot, thus: as 12 is to 10, ſo is one inch and 475, to 126 of a Foot in Decimals.

Then having the Diameter at each end, and the length, you are firſt to find the *Area* of the Baſe in foot-meaſure.

By the former Rule in the firſt *Example*; as 452 is to 355, ſo is the ſquare of 2:5, which is 6:25, to the *Area*, 4908, and the whole length of the Cone, 282, reduced into Foot-meaſure, will be 23:5.

Then divide that ſum by 3, and the Quotient will be 7:83, which being multiplied by the *Area*, 4:908 the product will be 38:42964, which is 38 foot and almoſt a half, for the content of the whole cone.

Then

Then find the *Area* of the leſſer end of the Piece, by the leſſer Diameter, which is 1:126, as you found the other, and it will be 0:995, which is not quite one foot, then find the length from the little end of the Piece, to the top of the cone; thus the length of the cone in foot-meaſure is found to be 23:5, from which take the length of the Piece 12:5, and the remainder is 11; and one third of 11, is 3:66. Then by this third of the length of the leſſer cone, you muſt multiply the *Area* of its baſe, 0:995, and the product is 3:64170, and this product taken from 38:429, the meaſure of the whole cone, then there will remain the true ſolid content of the Taper-piece of Timber 34:78730, or any other *Fruſtum* of a *Cone*.

EXAMPLE VII.

How you may find the ſolid content of a large round Tun, having the Diameter at the top and bottom given, and the depth of the Tun, which is alſo the *Fruſtum* of a *Cone*, and muſt be worked the ſame way before taught, as ſuppoſe the Dimenſions given to be theſe, (*viz.*) Diameter at the top, 128; Diameter at the bottom, 112, and the depth of the Tun 51 inches; you muſt firſt find the length of the cone,

that this Tun is a *Fruſtum* of, by the Rule of Three; then as the difference betwixt the top and bottom, 16, is to the depth of the Tun 51, ſo is the greater Diameter, 128, to the length of the Cone: Therefore multiply 128, by 51, produceth 6528, which being divided by 16, the Quotient is 408, the length of that Cone; then by the Diameter at the top of the Tun, you muſt find the *Area* of that Circle, as before directed, which will be 12868, almoſt; And one third of the length of the Cone, is 136; then multiply the *Area*, 12868, by 136, and the product is the ſolid content of the whole Cone in inches, (*viz.*) 1750048.

Then find the *Area* of the leſſer Diameter, which is 112, and it will appear to be 9852, then ſubſtract the depth of the Tun 51, from 408, the length of the whole *Cone*, and the remainder is the length of a leſſer *Cone*, (*viz.*) 357, of which take one third part, and by that multiply the *Area* of the bottom of the Tun, and the product will be 1172388, which is the Content of the leſſer *Cone* in Inches.

Then ſubſtract 1172088, from 1750048, and the remainder is 577660; and ſo many Inches are the ſolid Content of the Tun, in Cubical Inches.

Now if you would know how many Gallons this contains, you muſt divide 5577690, by

282,

282, and the Quotient will be 2048 Gallons, and a remainder of 124, which is almoſt half a Gallon, for if you multiply 124 by 8, the Number of Pints in one Gallon, the product will be 992, and that divided by 282, the Quotient will be 3, which is 3 Pints, and a remainder of 146, which is very little more then half a Pint; but I know not why any Perſon (eſpecially in great quantities) need to be ſo exact as to come to half a Pint, however let every man uſe his pleaſure.

Note, you may reduce theſe Gallons into Barrels of Ale, by dividing 2048, by 32, and the Quotient will be 64, which is the Number of Barrels of Ale the Tun will hold, having ſuch Dimenſions.

But if you are to take the dimenſions of any ſuch Tun, you muſt allow for the *Fall* or *Gathering* of the Tun, which may ſtand lower on the fore-ſide by two inches, more or leſs, from a true *Horizontal Plain* or *Level* of the Liquor: therefore it will be a very good way to find how much of the depth it taketh, and what Liquor it will contain, juſt to touch the oppoſite part of the bottom of the Tun againſt the *Fall* or *Gathering*.

This may be done by puting in of Liquor, with a true Gaged Kinderkin or Firkin till you ſee the bottom almoſt covered, and then it will

be

be convenient to uſe a Gallon, till you make it juſt cover, and when the Liquor hath done moveing, with your Rule take the depth of the place of Gathering, and what it comes to, muſt be abated out of the depth of the Tunn, and the Liquor put in by Meaſure, muſt be accounted into the quantity the Tunn will hold, ſo much more then the Dimenſions give.

You may find what Exciſe muſt be paid for this quantity of 64 Barrels, (or any other parcel) by the Rule of Three, for every 22 Barrels, pay but for 20, therefore ſay as 22 is to 20, ſo is 64 to 58 Barrels, and 18 parts of a hundred of a Barrel, which want a great deal of a Firkin; for if 18 had been 25, then it would have been a Firkin.

This may be of as good uſe to know the quantity of Money payable, without having any regard of reducing them to the payable Barrels, thus: As 22 Barrels are to the price that 20 pay for, ſo are any number of Barrels to the quantity of Money thereunto belonging. The Exciſe of Ale is now 3 s. 3 d. the Barrel, and 22 to the ſcore, which comes to 3 li. 5 s. then if 22 pay 3 li. 5 s. What ſhall 64 pay? Put the Money into a Decimal, and it will ſtand thus: 3:25, which Multiply by 64, the Product will be 208:00; to which you may add as many more Cyphers

phers as you pleaſe; I will therefore in this place add 4 more, and then it will ſtand thus: 208 : 000000; then divide by 22, and the Quotient is 9 : 454545, which being cleared, as before directed, will be 9 li. 9 s. 1 d. and ſo much the Exciſe comes to for 64 Barrels of Ale.

Strong Beer hath 23 Barrels to the ſcore, which pay equal with 22 of Ale; therefore the former Rule will ſerve, by putting 23 inſtead of 22, becauſe the Money for the ſcore is the ſame.

Small Beer hath alſo the allowance of 23 to the Score, and payeth 15 ſhillings for each 23 Barrels.

How to meaſure Piramids and their Bottoms or Fruſtums.

This ſort of Meaſure is the ſame almoſt with that of the Cone, for one third of the altitude, being Multipli'd by the Area of the Baſe, giveth the ſolid Content, and the whole length Multipli'd by half the breadth of all the ſide at the Baſe, is the Superficial Content, all the difference between a Cone and a Pyramid being only this; the Cone hath a circular Baſe, and the Pyramid may be of 3, 4, 5, or more ſides:

Now

Now to find the Area of a 3 ſided *Pyramid* or equilateral Tryangle; Cube the ſide, and Multiply that Cube by 1875, and off cut four places to the right hand, and what remains to the left hand; is the ſquare of the Area, the Root whereof, is the Area deſired.

This way of finding the Area of an Equilateral triangle, is in part borrowed from Mr. *Diggs* his Pantometria, page 59 and 60, but his hath a Diviſion in the work which is here avoided. There is another way to perform the ſame, which in my Opinion will be plain, (*viz.*) Square half one of the Sides, and alſo a whole Side, then ſubſtract the ſquare of half the Side, from the ſquare of the whole Side, and extract the ſquare Root of the difference between the ſquare of the Side and the half Side, and that Root will be the length of a Perpendicular, let fall from the oppoſite Angle to the middle of the Side you took the half of, then Multiply the half ſide by the length of the Perpendicular, and the product will be the Area: And this way I judg will be better underſtood then the former, and the extraction of the ſquare Root will be in a ſmaller number then the other way.

And if you cannot extract the ſquare Root by *Arithmetick*, you may do it by the Logarithm, at the latter end of the Book. Thus any number being

being given within the compaſs of ſo ſmal a Canon of Logarithm, there will be no more to do then to find the Logarithm of the number that you would have the ſquare Root of, then take the half of that Logarithm, or divide it by two, and next find what number doth anſwer to that half number or Logarithm, and the number found is the ſquare Root the number deſired.

To find the Area of a four-ſided *Pyramid*, is but to Multiply the ſide of the Baſe in its ſelf, and the Product of that Multiplication, is the Area of that Baſe, but if it be a *Pyramid* of many equal ſides, take half of the ſides, and multiply by half the Diameter, or diſtance from the Center of the Baſe, and that product will be the *Area*; But my intent is only to ſhew the way of Meaſuring Taper-Timber, which hath four ſides, either equal or unequal at the baſe or top.

EXAMPLE VII.

Suppoſe a piece of Timber to be meaſured, that is 2 foot, and 2 tenth parts ſquare at the baſe, and one foot and 3 tenths ſquare at the top or leſſer end, and the length 43 foot, and 5 tenths.

Firſt,

Firſt, find the length of the Pyramid; whereof this is a *Fruſtum*; then ſubſtract the ſide of the top from the ſide of the Baſe, and the difference is 9 tenths, then ſay, as 9 tenths is to 43:5, the length of the Piece, ſo is the ſide of the Baſe 2:2, to the length or height of the Pyramid 106:3, and one third part thereof is 35:4, and a little more, which is not conſiderable in Timber-meaſure.

The ſquare of the Baſe is 4:84. which is the *Area*, and 35:4, multiplied by 4:84, produceth 171:336, the Content of the whole Pyramid in foot-meaſure.

Then as this Pyramid was meaſured by the ſame Rule, you may meaſure the little Pyramid at the top of the Piece, whoſe Baſe there beginneth and endeth, therefore if you multiply 1 foot, 3 tenths, by 1 foot and 3 tenths, the ſum will be the *Area* of the Baſe of the leſſer Pyramid, *viz.* 1:69, then ſubſtract the length of the Piece of Timber, from the length of the whole Pyramid, and the remainder will be the length of the leſſer Pyramid; the length of the whole Pyramid is 106:3, and from that ſubſtract the length of the piece 43:5, and the remainder is the length of the leſſer Pyramid 62:8, then take one third part of 62:8, which is 20:93, and multiply that by the *Area* of this leſſer baſe, which is 1:69, and the product is

the

the ſolid content of the leſſer Pyramid 35:3717, ſo this leſſer Pyramid is 35 foot, and about 1 third part of a foot, then ſubſtract this leſſer Pyramid from the Lolodity of the greater pyramid, and their difference is the ſolid content of the Taper-piece of Timber deſired, ſubſtract 35:3717, the leſſer, from 171: 3360, and there remains for the Content of the piece of Timber 135 Foot, and 9643 parts of ten thouſand, which is almoſt 1 foot more and this as I promiſed in *Page* 27. to explain this when I come to the Rule of Three, cannot be meaſured, as being the *Fruſtum* of a pyramid, without the Golden Rule, if you are to find the height or length of the pyramid.

There is another way of meaſuring of Taper Timber, without finding the length of the pyramid, which may be done thus, finde the *Area* of the baſe, as before, to be 4:84 and alſo the *Area* of the top to be 1:69, then multiply 4:84 by 1:69, and the product is 8:1796, then extract the ſquare Root of 8:1796, which will be found to be 2:86, as you may with eaſe prove, though you cannot readily extract the Roots, for if you multiply 2:86 by 2:86, it will produce 8:1796. Now having this 3 Number, as 4:84 and 1:69, and the ſquare Root, *viz.* 2:86, add them all together, and their ſum when added will be 939, then

then take one third thereof which is 313, by this 313, if you multiply 43.5, the length of the piece of Timber, and the product will be 136.155, the ſolid Content of the piece.

Or if you take one third of the length of the piece, and multiply the ſum of the three Numbers added, the product will be the ſolid Content of the piece as before, you may ſee there is ſome ſmall difference betwixt the former way and this; there may well happen ſome little difference in taking of the thirds of the Pyramids, they not falling out to come even, but all that there is cometh not to 2 tenth parts of a Foot, which is near enough to truth.

There is yet another way to Meaſure Taper-Timber, which in my mind is very ready, and very eaſie, for you need not find the length of a Pyramid, nor extract any Root.

EXAMPLE IX.

Suppoſe a piece of Timber were to be Meaſured, which hath the ſame Dimenſions given as before, the ſide of the Baſe 2 Foot 2 tenths, and the ſide of the top was 1 Foot 3 tenths, then one Multipli'd by the other, makes 2 Foot 86 parts of a hundred, which is the ſquare Root that you were troubled to Extract, and it

it will always hold in any Numbers whatſoever, a product made by the multiplication of the ſide of the Baſe of a Pyramid, and the ſide of the top of any *Fruſtum* thereof, will be equal to the ſquare root of their *Area's* multiplied one by another.

Suppoſe the ſide of the 3 foot, and the ſide of the top 2 foot, the ſquare of the ſide of the baſe is 9 foot, which is the *Area* of the baſe, and the *Area* at the top will be 4 foot, and 4 times 9 is 36, and the ſquare Root thereof is 6, and you might have had this ſquare Root by multiplying the ſide of the baſe by the ſide of the top, which is 2 times 3 is 6, and in all ſuch Caſes you may uſe this manner in ſtead of the ſquare Root, as in the former way in the laſt Example, a Piece of Taper-Timber, the ſide at the But is 1 foot 5, and the ſide at the top of 0 foot 8 parts, and the length of the Piece is 35, and 7 parts, the ſquare of one foot and a half is 2 : 25, and the ſquare of 0 foot 8 is 0 : 64, and the product of the bottom ſide multiplied by the top ſide is 1 : 20, and theſe three added together makes 4 : 09 : then take one third of the length, *viz.* 3 : 57, which is 11 : 9, and multiply by 4:09, and that product is the ſolid Content, *viz.* 48 foot, and 671 parts, which is more then half a foot; I have been a little larger then ordinary in explaining of this

way of meaſuring of Taper-Timber, becauſe I do account it a great deal the eaſieſt way, and a way I think not commonly known, neither did I borrow it out of any Author or from any Friend, for if I had I would have owned it, and this I judg to be ſufficient for any that will give their minds to be perfect in this kind of *Arithmetick*. Which if you have well peruſed this Book ſo far as this place, you will find that Decimals are the beſt in meaſuring of Superficies or Solids.

EXAMPLE X.

I ſhall now I hope give you ſome ſatisfaction of my being ſo large in the Diviſion beforegoing, for I judg you might think it needleſs to divide pounds and parts of pounds by Numbers of the ſame Denomination, but what I have done there, will be uſeful in the Rule of proportion of pounds, ſhillings, pence and farthings, either for the increaſe or decreaſing of any ſtock of Money, according to the proportion of the gain or loſs of any ſtock propounded.

This will alſo be convenient for the finding the value of any quantity of Goods bought proportionable to ſome other quantity of ſo many pounds, ſhillings, pence and farthings, the quantity of the proportional Goods; or thus, if

327 pounds 18 ſhillings and 6 pence 3 farthings, bought 1234 Gallons of Wine, how much Wine will 43 pounds 12 ſhillings 3 pence 3 farthings buy, or if any quantity of Wine or any other Goods coſt any odd ſum of Money, how much muſt I pay for ſome other quantity of Wine or other Goods, I will explain this by Examples for the better underſtanding of the Reader.

If 23 pounds 11 ſhillings and four pence half penny give 47 pounds 19 ſhillings and 9 pence 3 farthings, how much will 3 pounds 17 ſhillings and 3 pence 3 farthings give in the ſame time? now for all the Fractions of pounds you muſt fit your ſelf with the Decimals properly belonging to them, as you may find them in the Decimal Table of *Engliſh* Coyn, in *page* 26. Turn the Table outward towards the left hand that it may be ſeen when any part of the Book is opened, and then you may readily take out the Decimal anſwering to any Fraction of a pound.

The Decimal of 11 ſhillings four pence half-peny is 568750, then before it towards the left hand, you muſt place 23, which is the pounds, and then the firſt ſum will ſtand thus, 23:568750, the ſecond ſum will ſtand thus, 47:990625, and the third ſum will ſtand thus, 03:865625, then multiply

the two laſt ſums one by the other, which is the ſecond and third, and their product will be 185:5137597656 25, you having ſix fractions of a ſide, which makes 12 in all, and ſo many places you are to mark off to the right hand, then divide this product by the firſt number, *viz.* 23: 5687500 and Quotient, can be but one place to the right hand pounds, for 23 cannot be had in 185 ten times, for ten times 23 is 230, which exceeds 185 the Diviſor, ſo the firſt Figure to the left hand will be pounds, and all the reſt a Fraction of a pound, as you may ſee by the Quotient, is 7:871175, and a remainder of 3884475, which cannot be expreſſed in *Engliſh* Coyn; but if you clear the Quotient of the Fraction, which is more then 7 pounds, you will finde it to be 17 ſhillings 5 pence, and not one farthing, but 328 parts of a thouſand of a farthing.

If a Stock of Money be made up among ſeveral men, of 576 pounds 11 ſhillings and 10 pence half-penny, and this Stock loſeth in the Trade it is employed in, 21 pounds 13 ſhillings and 5 pence farthing.

One of the Partners ſhare was 57 pounds 10 ſhillings 6 pence 3 farthings, what will be his ſhare of the loſs, in proportion of the whole anſwerable to his ſtock.

The Rule will ſtand thus, as the whole ſtock

is

is to the whole loſs, ſo is his Proportion of the ſtock to the quantity of money he is to loſe, for the ſtock he put in.

Finde all the Decimals anſwering to each fraction of a pound, and your Numbers will ſtand thus; as 576 : 593750 is in proportion to 21 : 671875, ſo is 57: 528125, to 2: 162254, which if cleared, will be 3 ſhillings and almoſt 3 pence, and ſo much will be the loſs of his ſhare of the ſtock; then ſubſtract 2 pounds 3 ſhillings and 3 pence, from 21 pounds 13 ſhillings 5 pence farthing, and the remainder will be 19 pounds 10 ſhillings 2 pence farthing, which is the money he is to receive back out of the aforeſaid ſtock.

If 327 pounds 18 ſhillings 6 pence 3 farthings, pay for 4 Tun, 3 Hogſheads, and 37 Gallons of Wine, how much will 43 pounds, 12 ſhillings, and 3 pence 3 farthings pay for?

Firſt, put the Wine all into Gallons, which is 1234, and the fractions of the pounds into Decimals, and the work will ſtand thus, as 327:928125 is to 1234 Gallons, ſo is 43:615625 to 164 Gallons and a fraction, remaining of 4146875, to which you may add as many Ciphers as you pleaſe, and divide as before directed, and you will have a Decimal Fraction of a Gallon, which may be cleared into Pints or leſs, as you pleaſe.

In ſtead of putting the Wine into Gallons, you may find the Decimal Fraction anſwering to three Hogſheads and 37 Gallons, which will be thus, 8968, and when Cleared it will be 7 Pints, and almoſt two tenths. This Rule is the ſame, if it be for a greater quantity then the firſt Sum, as this is a leſs.

You may invert this Rule thus, if any quantity of Wine coſt ſuch a ſum of money, how much money will any other quantity of Wine bring?

As thus, as 4 Tunn, 3 Hogſheads, and 37 Gallons is to 327 pounds, 18 ſhillings, 6 pence 3 farthings, ſo is 2 Hogſheads, 38 Gallons, 8968 parts of a Gallon, to 43 pounds, 12 ſhillings, 3 pence, 3 farthings, and after the ſame manner of working you may do any Queſtion for any other ſort of Goods, and ſo I conclude this Part, and proceed to the ſecond. The occaſion of my writing of this, was to make the Book of more general Uſe.

AN

AN

ESSAY

TO

Gunnery.

IN the Explanation, Uſe and Calculation of ſeveral Tables, not in any other Author, which will be a good Companion for ſeveral of His Majeſties Gunners, Shewing,

A very plain and eaſie Way how to Diſpart any true bored Piece, without uſing any *Callipars*.

Several Ways of Finding the Weight of Caſt Iron ſhot, or Shells, with a Table to every inch and tenth part thereof, to 20 inches Diameter, and how to find their ſolidity.

Alſo the quantity of Powder that any Shell will hold, with a Table Calculated to every tenth part of an inch Diameter.

Alſo a Table for the quantity of Powder, anſwering to each hundred weight of Metal, either for Iron or Braſs Ordnance, according to Ancient Cuſtom and Gunners Allowance.

The Manner of making of Cartridges without any former. The Diameter of the Cartridg being given, and weight of the Powder, to find the length thereof.

The Diameter and length given to finde the weight of Powder.

Weight of Powder and length given to finde the Diameter; and by their Circumference to find the ſame weight of Powder, &c.

A Table whereby you may with eaſe find out the bredth of any Cartridge, Calculated to every tenth part of an Inch.

Another Table ſhewing how far one Pound of Powder will fill any Cartridge, to every inch and tenth part.

Alſo a Table with the Names of 13 ſeveral Pieces of Cannon.

Names of Ordnance.	*Weight of the Powder.*
Height of the Bore.	*Length of the Cartridg.*
Diameter of the Shot.	*Bredth of the Cartridg.*
Weight of the Shot.	*The half Bredth.*

A Table of the Diameter of ſeveral Shots from 1 to 64 pounds.

The Uſe of the Gunners Quadrant.

The Uſe of a Sight-Rule, how to lay a Gun to

A Table to Diſpart any Piece of Cannon, Skell, by h

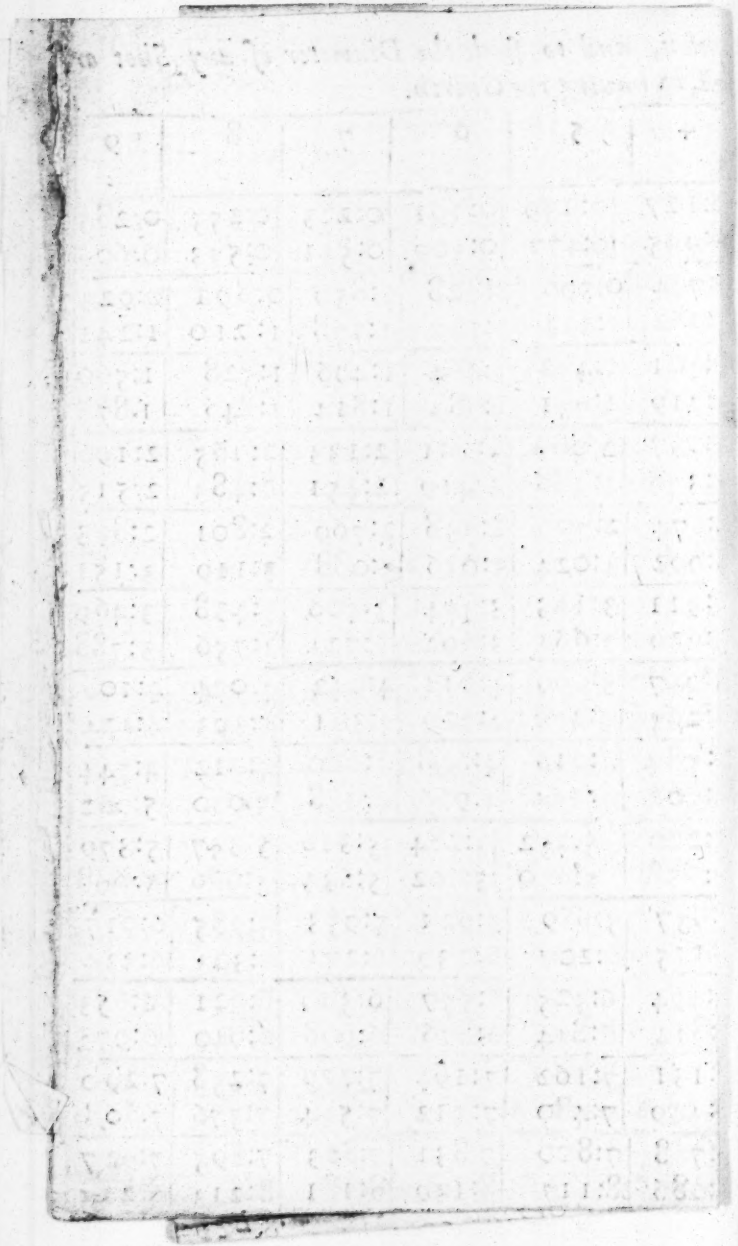
	0	1	2	3	4
0	0:000	0:032	0:064	0:095	0:127
1	0:318	0:350	0:382	0:413	0:445
2	0:637	0:668	0:700	0:732	0:764
3	0:955	0:986	1:919	1:051	1:082
4	1:273	1:305	1:337	1:369	1:401
5	1:592	1:624	1:655	1:687	1:719
6	1:910	1:942	1:974	2:005	2:037
7	2:228	2:260	2:292	2:324	2:356
8	2:547	2:579	2:610	2:642	2:674
9	2:865	2:897	2:920	2:960	2:992
10	3:183	3:215	3:247	3:279	3:311
11	3:501	3:533	3:565	3:597	3:629
12	3:820	3:851	3:883	3:915	3:947
13	4:138	4:170	4:202	4:234	4:265
14	4:456	4:488	4:520	4:552	4:584
15	4:775	4:807	4:839	4:871	4:902
16	5:093	5:125	5:157	5:188	5:220
17	5:411	5:443	5:475	5:507	5:638
18	5:730	5:762	5:793	5:825	5:857
19	6:048	6:080	6:112	6:144	6:175
20	6:366	6:398	6:430	6:462	6:494
21	6:685	6:717	6:749	6:781	6:812
22	7:003	7:035	7:067	7:099	7:131
23	7:321	7:353	7:385	7:417	7:449
24	7:640	7:672	7:704	7:736	7:768
25	7:958	7:990	8:022	8:054	8:086
26	8:276	8:308	8:340	8:372	8:404
27	8:595	8:627	8:659	8:691	8:723
28	8:913	8:945	8:977	9:009	9:041
29	9:231	9:263	9:295	9:327	9:359
30	9:550	9:582	9:614	9:646	9:678
31	9:868	9:900	9:932	9:964	9:996

…non, and to finde the Diameter of any Shot or …ll, by having the Guirth.

4	5	6	7	8	9
:127	0:159	0:191	0:223	0:255	0:286
:445	0:477	0:509	0:541	0:573	0:605
:764	0:796	0:828	0:859	0:891	0:923
:082	1:114	1:146	1:178	1:210	1:241
:401	1:432	1:464	1:496	1:528	1:560
:719	1:751	1:783	1:814	1:846	1.878
:037	2:069	2:101	2:133	2:165	2:196
:356	2:388	2:419	2:451	2:483	2:515
:674	2:706	2:738	2:769	2:801	2:833
:992	3:024	3:056	3:088	3:119	3:151
:311	3:343	3:374	3:406	3:438	3:469
:629	3:661	3:692	3:724	3:756	3:788
:947	3:979	4:011	4:042	4.074	4:106
:265	4:297	4:329	4:361	4:393	4:424
:584	4:616	4:648	4:680	4:712	4:744
:902	4:934	4:966	4:998	5:030	5:062
:220	5:252	5:284	5:316	5:347	5:379
:638	5:670	5:602	5:634	5:666	5:698
857	5:889	5:921	5:953	5:985	6:017
175	6:207	6:239	6:271	6:303	6:334
:494	6:525	6:557	6:589	6:621	6:653
812	6:844	6:876	6:908	6:940	6:972
131	7:162	7:194	7:226	7:258	7:290
449	7:480	7:512	7:544	7:576	7:608
768	7:800	7:831	7:863	7:895	7:927
086	8:117	8:149	8:181	8:213	8:245
404	8:435	8:467	8:499	8:531	8:563
723	8:754	8:786	8:810	8:850	8:882
041	9:073	9:104	9:136	9:168	9:200
359	9:390	9:422	9:454	9:486	9:518
678	9:709	9:741	9:773	9:805	9:837
996	10:027	10:059	10:091	10:123	10:155

21	6:685	6:717	6:749	6:781	6:812
22	7:003	7:035	7:067	7:099	7:131
23	7:321	7:353	7:385	7:417	7:449
24	7:640	7:672	7:704	7:736	7:768
25	7:958	7:990	8:022	8:054	8:086
26	8:276	8:308	8:340	8:372	8:404
27	8:595	8:627	8:659	8:691	8:723
28	8:913	8:945	8:977	9:009	9:041
29	9:231	9:263	9:295	9:327	9:359
30	9:550	9:582	9:614	9:646	9:678
31	9:868	9:900	9:932	9:964	9:996
32	10:186	10:218	10:250	10:282	10:314
33	10:505	10:537	10:569	10:601	10:633
34	10:823	10:855	10:887	10:919	10:951
35	11:141	11:173	11:205	11:237	11:269
36	11:460	11:492	11:524	11:556	11:588
37	11:778	11:809	11:841	11:873	11:905
38	12:096	12:127	12:160	12:191	12:223
39	12:415	12:446	12:478	12:509	12:541
40	12:733	12:764	12:796	12:828	12:899
41	13:051	13:082	13:146	13:178	13:209
42	13:370	13:400	13:432	13:464	13:496
43	13:687	13:719	13:751	13:783	13:813
44	14:006	14:038	14:070	14:102	14:134
45	14:325	14:357	14:389	14:419	14:451
46	14.643	14.674	14.705	14.737	14.769
47	14.961	14.992	15.024	15.056	15.088
48	15.280	15.310	15.342	15.374	15.406
49	15.598	15.629	15.661	15.693	15.725
50	15.916	15.948	15.980	16.011	16,043
51	16.235	16.268	16.300	16.332	16.364
52	16.553	16.585	16.617	16.649	16.681
53	16:871	16.903	16.935	16:967	16.993

12	6:844	6:876	6:908	6:940	6:972
31	7:162	7:194	7:226	7:258	7:290
49	7:480	7:512	7:544	7:576	7.608
68	7:800	7:831	7:863	7:895	7:927
86	8:117	8:149	8:181	8:213	8:245
04	8:435	8:467	8:499	8:531	8:563
23	8:754	8:786	8:810	8:850	8:882
41	9:073	9:104	9:136	9:168	9:200
59	9:390	9:422	9:454	9:486	9:518
78	9:709	9:741	9:773	9:805	9:837
96	10:027	10:059	10:091	10:123	10:155
314	10:345	10:377	10:409	10:441	10:473
633	10:664	10:696	10:728	10:760	10:792
951	10:982	11:014	11:046	11:078	11:110
269	11:300	11:332	11:364	11:396	11:428
588	11:619	11:651	11:683	11:715	11:747
905	11:936	11:968	12:000	12:032	12:063
223	12:254	12:286	12:318	12:350	12:382
541	12:573	10:605	12:637	12:669	12:700
899	12:891	12:923	12:955	12:986	13:019
209	13:241	13:273	13:305	13:305	13:337
496	13:528	13:560	13:592	13:624	13:656
813	13:845	13:877	13.910	13:942	13:974
134	14:166	14:198	14:228	14:260	14:292
451	14:483	14:515	14:547	14:579	14:610
769	14.801	14.833	14.865	14.897	14.929
088	15.119	15.151	15.183	15.215	15.247
406	15.438	15.470	15.502	15.534	15.566
725	15.757	15.789	15.821	15.853	15.885
043	16.075	16.107	16.139	16.171	16.203
364	16.396	16.428	16.460	16.492	16:523
681	16.713	16.745	16.777	16.809	16:840
993	17.029	17,061	17.093	17.125	17.156



to any Degree of Mounture, with a Table fitted to the length of any Gun, and every tenth part of a Degree to 21 Degrees, and 9 tenths of a Degree, with a very ready and exact way of finding any diſtance within common ſight, or any height, with a Table fitted for that purpoſe.

A very Eaſie and convenient Way to finde the Diſpart of any Peece of Ordnance, without any Callipars, *and as true.*

To perform this Work, you muſt have in readineſs ſome Piece of Ribbon or Tape, about five or ſix foot in length, to girt the Muzle of the Peece, and alſo the Baſe Ring; ſo that you may obtain the difference between the Circumference of the Baſe Ring and the Muzle Ring, the half of that difference will with eaſe quickly help you to the height of the Diſpart of any Peece of Ordnance, by the help of the Table hereunto annexed, Calculated for that purpoſe to every tenth part of an inch.

The Uſe of the Diſparting Table.

This Table hath eleven Columns, the firſt towards the left hand is a little one, Figured with

with, 0, 1, 2, 3, 4, and the laſt is 53. Which ſignifie Inches, the other ten Columns are noted at the Head with, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, which is every tenth part of an Inch, and under them is the heighth of the Diſpart to the 1000 part of an Inch, which I ſhall make very plain and eaſie by Examples.

EXAMPLE I.

Suppoſe the Girt or Circumference of the Baſe-ring of ſome Gun, was meaſured with ſome flat String as will not ſtretch, as a Ribbon, or Tape, and a Pin ſtuck in the Ribbon at the Girt, then Girt the Muzlering and ſtick a Pin at that Girt, then the difference betwixt the two Pins, will be the difference of the Circumference of the Baſe and Muzlering; take the half of that difference, which you may eaſily have by laying the two Pins together and doubling the Ribbon.

Then you muſt have in readineſs ſome Scale or Rule of a Foot long divided into Inches, and every Inch into ten parts, in which you muſt Meaſure this double Ribbon, that you may have the length thereof in Inches and Tenth parts of an Inch (*viz.*) which I find to be 9 Inches and 7 Tenths; then to find the heighth of the Diſpart, enter the Table in the little Column towards the left hand, look for 9 Inches, and guiding your Eye towards the right hand until you come under

under 7: at the Head of the Table, you will find at the Angle of Meeting, 3, 048, which is three Inches and almoſt half a tenth part of an Inch; which is the true heighth of the Diſpart for any ſuch Gun that hath ſo much difference in Circumference of the Baſe and Muzle-ring. But if a Gun be not true boared, the Diſpart may be faulty this way, or by the Callipars either; this way is as true as any Callipars, and much Cheaper, and a great deal more portable to carry, for you may have a Ribbon wound upon a Rowle like a Carpenters Line-Rowle, and put into a long round Tin or Copper Box, with a ſlit ſide for the Ribbon to be pulled out at, as little and as much as you pleaſe at a time; And alſo you may have a little Key like the Key of a Watch, to wind it up at the end of the Box, and a little turning the Cover of the Box will faſten the Ribbon at any length, or when it is quite Rowled up. The Foot Rule may have a Joynt, and ſo be very portable without trouble.

The Right Worſhipful Sir *Jonas Moor* hath put forth ſuch a Rule in his *Fortifications*, of that length, with many Lines of good Uſe in Gunnery, and Fortification thereon, made by Mr. *Marks* near *Denmark* houſe in the Strand. The Rowls and Boxes for your Girting Ribbon, you may have of me at my houſe, with or without Ribbons fitted to them. Take two or three Examples in a briefer manner. *Example*

EXAMPLE II.

Let the half Circumference betwixt the Baſe and Muzle Ring be found, (as by the firſt Example,) to be five inches, and three tenth parts of an inch; for which Number I look in the Table, and againſt five inches on the left hand, and under three Tenths I find 1,665, which is the height of that Diſpart, (*viz.*) one inch, 6 tenth parts, and a little more then half a tenth part, and this Diſpart will anſwer to any Gun that hath ſo much difference in Circumference.

EXAMPLE III.

If half the difference of the Girt or Circumference of the Baſe, and Muzlering on the Rule, and found to be ſeven Inches, and five tenth parts; then enter the Table at ſeven Inches, and under five tenths at the Angle of Meeting, I find, 2, 356 for the heighth of the Diſpart (*viz.*) two Inches, three tenths and a little more then half a tenth, and that is the true heighth of the Diſpart.

EXAMPLE IV.

Suppoſe that the difference of the half Girt of

of the Baſe, and Muzlering to be eight Inches and 1 tenth, againſt 8, and under one in the Table I find 2:545 for the heighth of the Diſpart, which is 2 Inches and a half and almoſt half a tenth. This Table may be put upon a Rule along by the Line of Inches, then you will have no more to do then to lay the two Pins together, and double the Ring, and apply it to the Rule, and you have the length of the Diſpart, by Meaſuring without the Table. You may have this Ruler made by Mr. *Brown*, living at the *Spear* and *Sun-Dyal* in the *Minories*.

SECT. II.

How this Table may be made at any ones leaſure, by ſuppoſing any Number of Inches to be the Circumference of the Baſering, and then by that Circumference, find the Diameter as you are taught in the firſt part of this Book, this as 355 is to 113, ſo is the Circumference to the Diameter; which will be the ſame as if curiouſly taken with a pair of Callipars.

Then by the ſame Rule that you found the Diameter for the Baſe, you muſt find the Diameter of the Muzlering, then when you have gained both the Diameters, ſubſtract the leſſer from the greater, and the half of that difference is the Tabular Number, or the heighth of the

Diſpart

Diſpart deſired. But this will be too troubleſome to be done, for every Gun and for every Gunner, as you will better underſtand by an Example or two.

EXAMPLE I.

The Compaſs of the Baſe-ring 66:35 (*viz.*) 66 Inches 3 Tenths, and half a tenth, and the Compaſs of the Muzle 47 Inches, 7 tenths and half a tenth.

Then find the Diameters of thoſe Circumferences, thus; firſt, for the Diameter of the Baſe 66:35 which I Multiply by 113, and the product is 7497.55, which muſt be divided by 355, and the Quotient is 21.119, ſo the Diameter of the Baſe-ring is 21 inches, and 119 parts of 1000.

The next for the Diameter of the Muzle-ring, the Circumference is 47.75, which multiplied by 113 the product is 5395.75, which being divided by 355, the Quotient is 15:199 parts of 1000. Thus having gained both the Diameters, ſubſtract 15:199, from 21:119, and their difference is 5:920, parts of 1000. The half of 5:920 is 2,960, which is the true height of the Diſpart deſired.

And by this Rule you may finde the height of any

any Diſpart, having the Circumference of the Baſe and Muzle-ring given; and you may as your leaſure make ſuch a Table, which if you work true, it will never differ one tenth from this, but this being made by the Logarithms, will come nearer to the truth in the Proportion to the Circumference to the Diameter.

EXAMPLE II.

Here I take the Circumference to be the ſame as before the Baſe 66, 35 and the Muzle 47, 75. Subſtract the leſſer from the greater, and the remainder is 18, 60. which ſuppoſe to be the Circumference of ſome Circle, then by the former Rule find the Diameter of that Circle, Multiply 113 by 18-60, and the product is 2101-80, which being divided by 355 the Quotient is 5·920, the half of which is 2-960 the heighth of the Diſpart as before.

EXAMPLE. III.

This way I take to be the eaſieſt of all, or at leaſt Equivolent with the former, thus, having the difference of the two Circles, the Baſe and Muzle-ring given 18-60. Take the halt, which is 9:30, and ſuppoſe that a Circle the Diameter thereof is the heighth of the Diſpart, Multi-

ply

ply 113 by 9--30, the product is 1050--90, which divided by 355, the Quotient is 2--960 the height of the Dispart.

SECT. III.

Having the Diameter of any cast Iron Shot, to find the Weight thereof.

MANY of our former Authors did allow a Shot of four Inches Diameter, to weigh 9 Pound weight, and gave that as a Proportion to all the rest, and thus was their way of working of any Shot. As the Cube of 4 Inches Diameter, which is thus found, Multiply 4 by 4 and it maketh 16, then Multiply 16 by 4, and it maketh 64, which is the Cube of 4 Inches. And so you must Cube any other Diameter the same way; First, multiply it by it self, and that is the square of the Diameter, then multiply that square by the Diameter again, and that product is the Cube of the Diameter. For their proportions are in their Cubes; as thus, As the Cube of 4 which is 64 is to 9 pound weight, so is 5 inches Diameter, the Cube whereof is 125--4057 pound, and 37 parts of 64, which is a little more then half a pound. The Work will stand thus

thus to be wrought; as 64 to 9, ſo is 125 to 17 and 37 parts.

Multiply 125 by 9, and the product is 1125, which divided by 64, the Quotient will be 17 pounds and 37 parts of 64.

Another Way of Finding the Weight.

This Way will ſave you the labour of making any Proportion, for it is all done by Multiplication thus, Cube the Diameter, and multiply that product by 14, and cut off the two laſt Figures to the right hand, and thoſe Figures remaining towards the left hand are pounds, and the Figures cut off are parts of 100 of a pound.

This way I had of my very worthy Friend Captain *Valentine Pyne*, Maſter-Gunner of *England*. And I have alſo Weighed ſeveral Shots, and I do find them nearer to this Proportion then the former. The reaſon of this 14 I ſuppoſe is, that it comes of the two former Proportional Figures, (*viz.*) 64 and 9, for if you add 2 Cyphers to the 9 it will be 900, and divide it by 64, the Quotient will be 14; and if you add another Cypher, there will be but a Cypher the more in the Quotient, thus, 140, and in this Caſe 14 is as good as 140.

EXAMPLE I.

Let the Diameter of the Shot be 5 inches, whoſe ſquare is 25, and that multiplied again by 5 giveth the Cube to be 125, and this multiplied by 14 the product is 17,50, which is thus, 17 pounds and a half juſt. Which differeth very little from the other way, and this a great deal the eaſier and the ſooner done, and by ſeveral trials that I made, this is nearer the truth.

EXAMPLE II.

A Shot whoſe Diameter is 5 inches and 1 tenth part of an inch, which will ſtand thus, 5:1 multiplied by 5:1 the product will be 26-01, and this is the ſquare of 5 inches and 1 tenth, which multiplied by 5 and 1 tenth giveth 132-651, the 3 tenths cuts off three Figures to the right hand: when it is multiplied by 14 you muſt cut off five Figures to the right hand, 3 for the 3 Fractions, and 1 for the 14 as before directed; when multiplied by it, it makes 18.571 14, which is 18 pound and a little above a half, and ſo you may uſe any tenth parts, what you pleaſe.

Ex-

EXAMPLE III.

Let the Diameter of a Shot for a Cannon of 7, be 6 inches and 7 tenths, and the weight thereof required: Firſt, multiply 6:7 by 6:7, and the product is 44:89, which being multiplied by 6:7, the ſecond product is 300:863, which is the Cube of the Diameter. Then multiply 300:863 by 14, and the product is 42-12802, which is 42 pounds, and the five Figures cut off are the Decimal Fraction of a pound; and if you would know how many Ounces it will make, you may multiply 12082 by 16 the ounces in one pound, and cut off five Figures to the right hand, and what remaineth to the left hand is ounces; as you may ſee the product will be 1:93312, which is almoſt two ounces, and ſo you may make a Table of Shot ſuch as is here annexed, which beginneth at one inch, and ſo to every tenth part of an inch to 20 inches, and 9 tenth parts of an inch, which is bigger then any Mortar-piece that I know. This Table will need but little Deſcription, only this, it hath 11 Columns, the firſt towards the right hand is a little Column, beginning with one and ending at 20: and the other 10 Columns be noted at head with 0. 1. 2. 3. 4. 5. 6. 7. 8. 9. which ſignifie every tenth part of an inch, belonging to the inches in the little Column,

whereby you may finde the Weight of any Caſt Iron ſhot, having the Diameter in inches and tenth parts by inſpection; this for Example, I would know the Weight of a Shot, whole Diameter is three inches, and three tenth parts of an inch. I look for 3 in the little Column, and looking along that Line till I come under 3 tenths at the Head of the Table, and in the Angle of meeting I find 5-27, which is five pound and a little above a quarter of a pound, for had the 27 been but 25, it had been juſt a quarter of a pound. But if you would expreſs it in Pounds, Ounces, Drams, Scruples and Grains, you muſt multiply 27 by 16, and cut off two Figures to the right hand, and the Figure or Figures to the left hand are Ounces, and then multiply the two Figures cut off by 8 by reaſon of 8 Drams make one Ounce, and cut off two Figures to the right hand, and what remains to the left hand is Drams, then Multiply the two Figures cut off by 3, for 3 Scruples make one Dram, & cut off two Figures again to the right hand, and what remains to the left hand is Scruples; then to conclude, multiply the two Figures cut off by 24, for 24 Grains make one Scruple, and cut off two Figures to the right hand, and what you have remaining to the left hand is Grains, and the laſt two Figures that were cut off, are ſo many parts of

100 of a Grain. I ſuppoſe there will be but little occaſion for this curioſity in the working of any ſuch Shots, for it will be a very hard matter to finde two Shots, (though both made in one Mould) that ſhall weigh exactly alike, but this may be of good uſe, for the better underſtanding how to clear any Decimal Fraction, and therefoie I will demonſtrate the working of it.

EXAMPLE IV.

Multiply 27 by 16, the Product will be 4,32 which is 4 Ounces, then multiply 32 by 8, and it yields 2 56, the 2 is 2 Drams, and 56 multiplied by 3 is 1-68, the 1 is 1 Scruple, then 68 multiplied by 24, the Product is 16-32, the two firſt Figures are 16 Grains, and the 32 is 32 parts of 100. So the weight of the ſhot will be 5 pounds, four ounces, 2 drams, 1 ſcruple, 16 grains, and 32 parts of 100 of one grain, and by the ſame manner of working you may ſatisfie your ſelf in the weight of any ſhot that you calculated the weight of, or took the weight from this Table.

EXAMPLE V.

If the Diameter be 5 inches, and 1 tenth of

an inch. *I* would know the weight thereof by this Table; Look in the little Column for 5, and guide your eye along the line till you come under 1 tenth at the head; and in the Angle of meeting is 18:58, (*viz.*) 18 pounds and a little more then half a pound, or 58 parts of 100 of a pound.

EXAMPLE VI.

Let the Diameter of a ſhot be 6 inches, and 7 tenth parts of an inch; I look in the little Column for 6 inches, and look ſtraightly along that line till I find 7 at the head of the Table, and in the Angle of Meeting I find 42:11, which is 42 pounds, and 11 parts of 100 of a pound, and ſo by finding the inches in the little Column, and the tenth parts of an inch at the Head of the Table of any Shots Diameter, at the Angle of Meeting you may have the weight of the Shot in pounds, and the 100 parts of a pound. But you muſt underſtand, though the Table will give you the weight of a ſhot, that is above 20 inches Diameter, yet I know no long Guns that will carry a ſhot that is 8 inches Diameter; therefore you muſt underſtand the Table is fitted for to give the weight of Granado-ſhells,

as

as well as ſolid Shot, they being both made of Caſt iron, which muſt be known by firſt having the Diameter of the Shell from out to out, and to that Diameter find the weight of the Shell, as if it were a ſolid Shot, then finde the Diameter of the inſide of the Shell with a Rule put in at the Fuſe-hole, or by the thickneſs of the Mettal at the Fuſe doubled and ſubſtracted from the outſide Diameter, will give the Diameter with the inſide, if the Shell be of an equal thickneſs, then having gained that Diameter by the Table, find the weight anſwering thereunto; then ſubſtract the leſſer weight from the greater, and the remainder is the weight of the Shell, as I ſhall make more plainly appear, as followeth.

EXAMPLE VII.

If the Diameter of a Shell from the outſides be 18 and 4 tenths, the weight of a ſolid Shot by this Table will be found againſt 18 inches in the little Column, and under 4 tenths at head in the Angle of Meeting, to be 872 pounds and 13 parts of 100 of a pound.

Then let the Diameter within the inſide of the Shell be 13 inches, and 6 tenths of an inch, againſt 13 and under 6 at the Angle of meeting, I finde 351-80, or 351 pounds and 80 parts of 100 of a pound, which being ſubſtracted from the former weight 872-13, their difference is 520 pounds and 33 parts of 100 of a pound, and ſo much will be the weight of ſuch a Shell of ſo much Diameter and 2 inches, and 4 tenth parts of an inch thick, you may abate out of this weight ſo much Mettal as the Fuſe hole. How you may finde the ſolidity or Number of Cubical inches in any Bullet or Shell, the common way is to Cube the Diameter, and multiply it by 11, and divide that product by 21, and the Quotient is the Number of ſolid inches, as will more plainly appear, as followeth, by

EXAMPLE VIII.

Take the Diameter to be 18 inches and 4 tenth parts of one inch, Multiply 18-4 by 18-4 and it gives 338-56, which being multiplied by 18-4. the product is 6229-504. which being multiplied by 11, the laſt product will be 68524:544, then divide this laſt by 21, and the Quotient is 3263:533, and 11 remains, which is of no uſe, for here is 3 Decimals already, which is near enough the truth; then the ſoli-

dity

dity of a ſhot of 18 inches and 4 tenths Diameter, will be 3263 ſolid inches, and 533 parts of a thouſand o an inch, which is above half an inch, and a third of a tenth part. Then by the ſame Rule finde the Number of inches in a Shot, whoſe Diameter is 13 inches and 6 tenths, as in the former example. For the weight of Shells. I have ſhewed you 2 ways of finding the weight of a Shot, by having the Diameter given. I will alſo give you another way to finde the ſolidity without any diviſion.

SECT. IV.

How to finde the ſolidity of a Shot without Diviſion, having the Diameter.

This way is ſoon expreſſed; you muſt firſt Cube the Diameter, and then multiply that product by 5238, and cut off four Figures to the right hand, as you did by finding the weight of the ſhot in cutting off two Figures; but if you have any Fractions you muſt cut off ſo many the more Figures as you have Fractions, which in this kind of work will alwa s be 3 Figures, for if there be one in the Diameter, there will be 2 in its ſquare, and there will come one more in the Cube, which will in this kind of work always be 3 Figures, or none at all

all; for in the laſt Example, the Diameter given is 18 Inches and 4 tenths, and the ſquare is 338 Inches and 56, which is two Figures of a Decimal Fraction, and the Cube thereof is 6229 and 504, which is a Decimal Fraction of 3 places, and this being to be Multipli'd by a Fraction of 4 Figures or places, there muſt be cut off 7 Figures or places to the right hand; for 6229:504 Multipli'd by 5238, the Product will be 3263--0141952, which differs from the former way about half an Inch leſs. But if you uſe 52381, it will come nearer the truth, and be ſomething to much reaſon, that the Cube of the Diameter being multiplied by that Number, is becauſe that 523 inches and almoſt 81 parts is the ſolidity of a Shot or Ball of 10 inches Diameter, as you may with eaſe prove the Cube of 10 is 1000, which being multiplied by 11 makes 11000, and this divided by 21, the Quotient will be 523 inches and 17 parts of 21, which you may put into a Decimal Fraction thus; as 21 is to 100, ſo is 17 to 80 and 20 parts of 21, which may very well paſs for 81; and ſo I hope I have ſatisfied you of the reaſon of this Number, and if you have occaſion you may multiply the Cube of any Diameter by the four Figures, or by the five Figures, which you pleaſe, either of them will be

near

near enough for common uſe. If you uſe the 4 Figures, and the Cube of 12 inches and 6 tenths, the product will be 1047: 7969488, ſo the ſolidity of that Ball may well paſs for 1048 Cubical inches; ſo the difference betwixt this and the other larger is 2215 Cubical inches, and about an half, which is the ſolidity of ſuch a Shell, except the Fuſe-hole; Methinks I hear you Gruntle at the reading of this ſubject, as if it concerned not a Gunner to meddle with, therefore I ſhall acquaint you of ſome very good uſe may be made of it.

On the 16th. of *January* 1672. I weighed ſeveral ſorts of Powder, at his Majeſties Tower of *London*, I having provided the year before a dry well-ſeaſoned Wainſcot Box, of a regular Form, by which we meaſured the powder as equally as we could, and of 4 or 5 ſorts, none of them were alike, but the large corned powder was heavieſt, the reaſon I judge, it had moſt Salt-Peter in it, and as near a proportion as I could make betwixt them all, one pound of Powder will be 31 Cubical inches, and ſix parts of 100, which is a little above half a tenth of an inch, and I will ſhew you that your ſolid inches are of uſe now, for to finde how much Powder you muſt have to fill any ſhell.

The

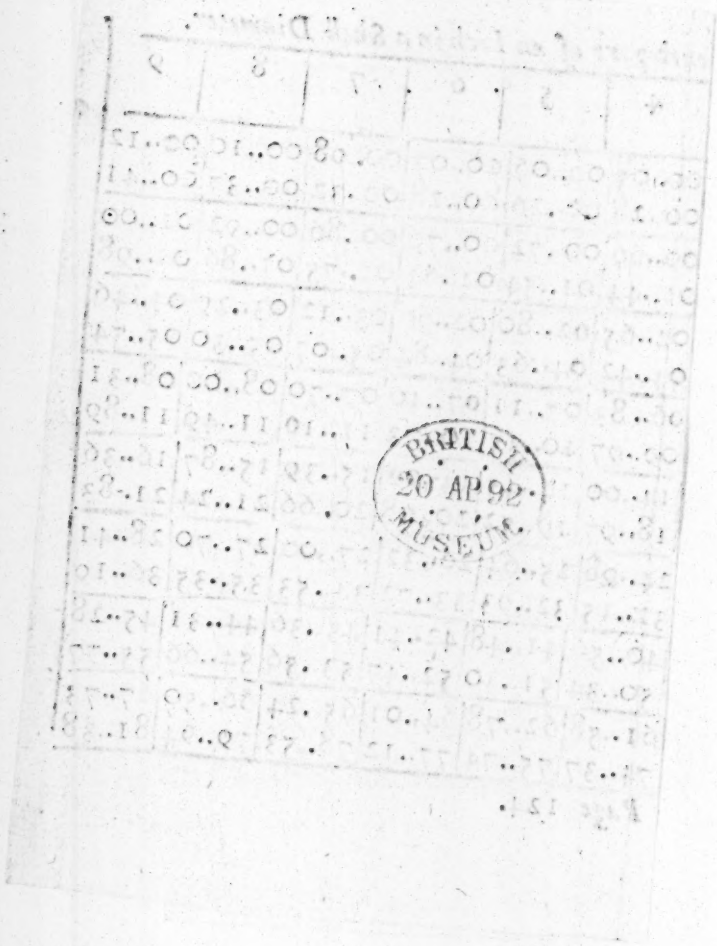
The Cubical Inch in the former Ball, muſt be equal to the hollow Cavity of ſuch a Shell, which hath the ſame Diameter within (*viz*) 12 Inches and 6 tenth parts, the ſolidity thereof I owned to be near 1048 Cubical Inches. Now to know how much Powder will fill this Shell or any other, take this General Rule, if 31 Inches and 06 parts of a 100 gives one pound, how many pounds will any Number of Cubical Inches require. Or thus, divide the Solid or Cubical (which is all one) Inches contained in this Shell by 31:06 the Cubical quantity of one pound of Powder, and the Quotient is the Number of pounds the Shell will hold, which will be the thing deſired.

EXAMPLE IX.

The Number of Cubical Inches and ſome of the parts (*viz*) the firſt 4 of them, the Number will be thus, 1047--7969, which I muſt divide by 31:06, and the Quotient will be 33 pounds and 73 parts of a pound, which is almoſt three Quarters; and by the ſame Rule you may find what quantity of Powder will fill any Shell if it be truly round, ſo near as this Proportion could then be gained. This work will to many Gunners be very troubleſom they many of them not underſtanding much *Arithmetick*,

A Table of Powder to every tenth part of an Inch in a Shell Diameter.

	0	1	2	3	4	5	6	7	8	9
01	00..01	00..02	00..03	00..04	00..05	00..06	00..07	00..08	00..10	00..12
02	00..14	00..16	00..18	00..20	00..28	00..26	00..28	00..32	00..37	00..41
03	00..45	00..50	00..55	00..61	00..66	00..72	00..79	00..86	00..92	01..00
04	01..08	01..16	01..25	01..34	01..44	01..54	01..64	01..75	01..86	01..98
05	02..11	02..22	02..37	02..51	02..65	02..80	02..96	03..12	03..29	03..46
06	03..64	03..83	04..02	04..17	04..42	04..63	04..84	05..07	05..30	05..54
07	05..78	06..03	06..29	06..56	06..83	07..11	07..40	07..70	08..00	08..31
08	08..65	08..96	09..30	09..64	09..97	10..35	10..73	11..10	11..49	11..89
09	12..29	12..70	13..13	13..56	14..00	14..45	14..92	15..39	15..87	16..36
10	16..86	17..35	17..89	18..42	18..97	19..52	20..08	20..66	21..24	21..83
11	22..44	23..06	23..69	24..32	24..98	25..64	26..32	27..00	27..70	28..41
12	29..14	29..87	30..57	31..37	32..15	32..93	33..72	34..53	35..35	36..19
13	37..04	37..91	38..77	39..67	40..56	41..48	42..41	43..36	44..31	45..28
14	46..26	47..26	48..27	49..30	50..34	51..40	52..47	53..56	54..66	55..77
15	59..90	58..04	59..21	60..39	61..58	62..78	64..01	65..24	66..50	67..78
16	69..06	70..36	71..68	73..02	74..37	75..74	77..12	78..53	79..94	81..38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metiek, and very few of them that know how readily to work by *Decimal Arithmetick*. Therefore I have long ſince taken the pains to Calculate a Table where they may be preſently ſatisfied by inſpection, which I hope may be of very good Uſe to the Mortar-piece belonging to his Majeſty in this Nation, or elſewhere.

SECT. V.

Explanation in this Table.

This Table differs nothing in form from the other of Shot, it hath 11 Columns. The firſt is a little Column to the left hand, beginning with 1, and ending with 16, which ſignifie Inches; the Figures at the top of the Table are the tenth parts of an Inch, from 0. 1, 2, and the laſt is 9, ſignifying 9 tenths of any of thoſe Inches in the firſt Column, and all the 10 middle Columns have two Rows of Figures, the firſt to the left hand ſignifie pounds of powder, and them on the Right hand are Decimal parts of a pound; this Table will ſerve for a Shell of almoſt 17 Inches Diameter within, and I never yet ſaw any ſo big, therefore no doubt but it will fit any.

The

The Uſe of this Table of Powder.

The Uſe it is for, is to ſhew how much powder any *Granado*-ſhell will hold; which is thus to be underſtood. You are firſt to meaſure what Diameter the Shell is within ſide, which ſuppoſe you have found to be according as the former Example was, the Diameter being 12:6 and I would find by the Table how much powder that Shell will hold.

EXAMPLE I.

I look in the little Column on the left hand for 12, and then guiding my Eye along that Line, till I come under 6, and in the Angle of Meeting I find 33-72, which differeth but one part of 100 from the work in the former Example, which was 33 pounds and almoſt 3 quarters of a pound, and ſo of all the reſt.

EXAMPLE II.

Suppoſe I had ſome ſmall Hand *Granado*-ſhell, the Diameter within is 2 inches and 3 tenths. I look in the little Column and find 2, and in the ſame line under 3 at the top, at the Angle of

of Meeting I finde 00:23, which is 20 parts of 100 of a pound, multiply 20 by 16, and the product is 3:20, which is three ounces, and the twentieth part of an ounce, which is a little above a dram and a half.

SECT. VI.

How much Powder ſhould be allowed to every hundred Weight of Metal, if a Gun be well Fortified, be it for Braſs or Iron Peeces.

A Gun is well Fortified when her Metal at the Vent or Touch-hole is as thick as the Diameter at her Bore. And moſt of the ancient Sea-Gunners do allow three ounces of powder for every hundred weight of Metal in Iron Guns, and 4 ounces of Powder for every hundred weight of Metal in Braſs Guns, then at that allowance to find how much powder an Iron Gun will require, that is, 53 hundred weight, multiply 53 the Weight of the Gun by 3 the Ounces of Powder, and the product is 159, which is the Number

Number of Ounces the Gun will require, then divide 159 by 16 the Ounces in 1 pound, and the Quoti nt is 9 and 15 remains, which is 9 pounds and 15 ounces, the Guns allowance by that proportion. This may be done by one Multiplication; If you multiply the Number of hundreds of Mettal by 1875, and cut off four Figures to the right hand, what remains to the left hand is pounds, and the other a Decimal Fraction of the 10000 part of a pound. If you multiply 1875 by 53, the product is 9:9375, and the like for any other weight: and if you multiply the Fractions cut off by 16, the ounces in a pound the product, will be 15:0000, exactly agreeing with the other way.

The finding the Allowance for braſs Guns, will be very eaſie any way, the Allowance being juſt one quarter of a pound to every hundred weight, you need but divide the weight of the Peece in hundreds by 4, and the Quotient is your anſwer. As if a braſs Peece were 53 hundred weight, that divided by 4, the Quotient will be 13 pounds, and one quarter, or four ounces; this may alſo be done by Multiplication. For if any Number of hundreds of weight be multiplied by 25, and two Figures cut off to the right hand, what remains to the left hand are pounds, and the Figures cut off are a

De-

Decimal Fraction of the hundredth part of a pound: As if 53, the weight of hundreds of the Gun, be multiplied by 25, the product will be 13,25, which is 13 pounds and 25 parts of 100, which is juſt one quarter-part of 100, and therefore one quarter of a pound or four Ounces. The ſame may be done for the weight of any braſs Peece of Ordnance, although the proportion of Powder to any Iron or braſs Gun may be eaſily found by theſe former Rules, yet it will be a great deal eaſier by inſpection; And therefore I have made this Table hereunto annexed, whereby you may have the quantity of powder, of either Iron or braſs Guns to every hundred weight of Metal, beginning with 10 hundred, and ending with 73 for Guns of leſs weight, and Guns of bigger weight will not be much uſed. The firſt Table is for Iron Guns, and hath two little Columns, the firſt to the left hand, and the third marked at the head with C, which ſignifies hundreds, and the ſecond and fourth Column is marked at the head with P and O, the P ſignifying pounds, and the O denoting the other part of thoſe Columns under O to be Ounces.

If you would know how much powder an Iron Gun of 53 hundred weight will require, at 3 Ounces to every hundred weight of Metal, look in the ſecond little Column under C downward

ward till you finde 53, and over againſt it to the right hand you will finde 9: 15, and over 9 at the head P, and over 150, which informs you that the 9 is 9 pounds, and the 15 is 15 Ounces, and ſo much powder will that Gun require. The Table for braſs Guns hath the very ſame order, and againſt 53 there, you will find 13 pounds and 4 ounces for that Guns allowance of powder.

Now I have laid down ſeveral ways how to find how much powder many Ancient Gunners do allow to an Iron, or a braſs Gun, according to the weight of her Metal. I think it will be very convenient to inform you how to find, what length any Cartridge muſt be filled with powder, to hold this or any other allowance; The way to do this, muſt be to finde the *Area* or Superficial Content of a Circle anſwering to the Diameter of the Shot, or the Bore of the Peece; but the Shot will do beſt if it be not too low, for all Cartridges muſt be lower then the Bore of the Peece, & muſt be made Tape-ring, that is, leſs at the bottom then at the top, and the Diameter that you muſt uſe muſt anſwer to about the middle of the Cartridge, or otherwiſe your work will be very erroneous, if you take either the Diameter at the top or at the bottom, then you muſt take them both, and finde a *Medium*; and ſuppoſe that to be the Diameter of a

Cilinder

Cilinder, which will nearly anſwer your deſire, in this caſe without any conſiderable errour; (though the Cartridge it ſelf is a Fruſtrum of a Cone, or round Pyramid) but ſo near a Cilinder, that in the higheſt of Cartridges the difference of the Diameter betwixt the top and the bottom of the Cartridge, will ſcarcely be half an inch, which can be but a quarter of an inch in the middle of it; then having (with theſe Cautions) found your Diameter, you muſt finde your *Area* thus; ſquare the Diameter, and then multiply it by 11, and that product being divided by 14, the Quotient is the *Area* of the Circle, anſwering to that Diameter. Or thus, ſquare half the Diameter, and multiply it by 22, and divide that product by 7, and the Quotient is the *Area*.

Another way and nearer the truth, is thus; Square the Diameter, and then multiply it by 355, and divide that product by 452, and the Quotient is the *Area* deſired.

It will not be amiſs to lay down a Rule by having the Circumference or Girt of the Shot to find the *Area*, for you may very eaſily Girt the Shot with a Ribbon or Tape, as you were directed in the Diſparting of the Gun, thus, ſquare the Circumference, and multiply it by 7, then divide that product by 88, and the Quotient is the *Area*.

EXAMPLE I.

Let the Diameter given be 4 inches, which being ſquared makes 16, which being multiplied by 355 produceth 5680, which being divided by 452, the Quotient is 12 inches and 57 parts of 100 of one Inch, the *Area* deſired. Then let the Allowance of powder be 6 pounds, and the Cubical or ſolid inches in one pound of powder is 31:06, which being multiplied by 6, the product is 186:36, and this divided by the *Area* 2:57, the Quotient is 14:825, which is 14 inches and 8 tenth parts and a quarter of a tenth, the length of a Cartridge, when filled with powder. Or ſo far will 6 pounds of powder fill ſuch a Cartridge.

This Work is very troubleſome, and not quickly underſtood, therefore I am deſired by ſome Friends and Acquaintance to beſtow a little more pains then ordinary, to explain this Cartridge work by ſeveral Examples; for I am of that conceit that you have it not in any other Book.

How you may prove the former work, and find the Area *of the Circle in the Decimal of a Pound of Powder.*

To perform this, you muſt add two or three Cyphers

Cyphers to the *Area* before found in inches, and when you have ſo done, you muſt divide it by the Cubical Inches in one pound of powder, and that Quotient muſt be multiplied by the length of the powder in the Cartridge before found, and that product will produce your 6 pounds of powder with Cyphers, or ſome very ſmall Fraction, and ſo you will finde this to be the inverſe Rule to the former, which was in effect thus.

Queſtion I.

The Diameter of the Cartridge, and the length (when filled with powder) being given, to find the weight of powder therein contained?

EXAMPLE II.

The Diameter given 4 inches, whoſe *Area* (as before found) is 12:57. Add to it 2 Cyphers, and then it will be thus, 12:5700. Then divide it by 31:06, and the Quotient is 0 405, which is the Decimal part of one pound of powder, or 405 parts of 1000 of one pound. Then take the length of the Cartridge given, 14,825, and multiply it by 405, and the product will be 6:004125, the firſt Figure thereof is the 6 pound deſired, and the other 6 Figures

are a Decimal Fraction of a pound.

For if you will take notice the 405 are 3 Fractions, and in the length of the Cartridge there is 14 inches, and 825, which 825 is 3 Fractions, which in all make 6 Fractions, and ſo many Figures you muſt always cut off as there is Fractions, as you were directed in finding the weight of a Shot, and this Fraction will make the powder too much by one Scruple and 15 Grains, as you may find if you clear the Fraction, as before directed, which is near enough the truth in any reaſon.

Queſtion II.

The Diameter of the Cartridge given, and the Pounds of Powder to find the length of the Cartridge, when filled.

EXAMPLE III.

The Diameter given is 6:3, and the quantity of powder 14 pounds and a half, and the length of the Cartridge deſired, thus, ſquare the Diameter, gives 39:69, and the proportion in the Golden Rule is thus, If 452 give 355 what 39:69 give. Always in the direct Rule of Three, you muſt multiply the two laſt Numbers together, and divide by the firſt, and the fourth

fourth Number is the ſum deſired, as here in this Example 355, and 39:09 are the two laſt, the product of their Multiplication is 14089:95, which being divided by 452, the Quotient is 31:172, which is the *Area* of the Circle, whoſe Diameter is 6 inches, and 3 tenth parts of an inch

Then the next will be to multiply the Cubical inches in one pound of powder, which is 31:06, by the weight of the powder allowed, which is here 14 pounds and a half, or 14:05, and their product is 450:370, which muſt be divided by 31:172, the *Area* of the Circle, and the Quotient is 14:447, ſo the length of the powder in the Cartridge will be 14 inches, 4 tenths, and almoſt half a tenth, which is the Anſwer to the Queſtion, or the thing deſired.

I have already ſhewed a way how to prove this by the demanding of another Queſtion: There is alſo another way of proving of this by a third Queſtion, which will alſo be very uſeful in the Arithmetical part of Gunnery, for without Arithmetick there can be little done in Gunnery, but the laborious part.

Queſtion III.

The Weight of the Powder, and the length of the Cartridge given, to finde the Diameter of the ſame.

Take the Number of Cubical Inches that all the Powder makes, and divide that ſum by the length of the Cartridge, and the Quotient will give you the *Area* of the Circle, of which Circle you muſt find the Diameter by the *Area* thus, as 355 is to 452, ſo is the Cubical inches and parts of the *Area* to the ſquare of the Diameter.

EXAMPLE IV.

If the Weight of the Powder be as in the laſt Example, 14 pounds and a half, the Number of Cubical inches was found to be 450:376, which muſt be divided by the length of the Cartridge 14:447, and the Quotient is 31:172, which is the *Area* of the Circle, which being multiplied by 452, produceth 14089:744, which being divided by 355, the Quotient is 39:6894, which wants 6 parts of 10000 of being the perfect ſquare, as it was at firſt; for the ſquare of 6:3 is 39:69, which is ſo near the

the truth as need at any time be deſired.

EXAMPLE V.

Queſtion IV.

Let the Circumference or Girt of the Shot be given, and the Weight of the Powder to find the length of the Cartridge.

Circumference 16:03 weight of the Powder 8 pounds 4 ounces, the Cubical inches in one pound of powder, 31:06. This is ſuppoſed to be given in all the other Queſtions; for there muſt be a third thing known to find out a fourth. The Circumference ſquared is 256·9609 which being multiplied by 7 produceth 1798:7263, which muſt be divided by 88, and the Quotient is 20:440, which is the *Area* of the Circle. Then by the Weight of the Powder, find the Number of Cubical inches therein: Weight of the Powder 8:25, which multiply by 31:06 produceth 256:245, which being divided by the *Area*, 20:440, the Quotient will be 12:444, the length of the Powder in the Cartridge will be near 12 inches and a half; and this you may prove either of the former ways, or by having the Circumference or Girt of a ſhot as well as with the Diameter.

Queſtion

Queſtion V.

How to find the bredth of a Cartridge when ſpread open. This is very eaſie and little made uſe of, for the general way of making of Cartridges is upon a Former, which is a piece of round Wood about 15 or 16 inches long, which is fitted to each Gun, on which they make their Cartridge either of paper or canvaſs.

The bredth of a Cartridg may be found thus, as 113 is to 355, ſo is the Diameter to the Circumference, which is the bredth of the Cartridge deſired; but let that bredth be about 3 or 4 inches from the Top, and ſo leſſer downwards, a Sacar Cartridge may be leſs in compaſs at the bottom then it is at the top, by one inch or better; and a demi-Cannon may be about two inches leſs at the bottom then it is at the top.

EXAMPLE VI.

A convenient Diameter for a demi-Cannon will be ſix inches, and two tenth parts; then to find the bredth of the Cartridge, multiply 62 by 355, the product is 2201, which muſt be divided by 113, and the Quotient is 19:478, which

is

is 19 inches and almoſt a half, and that may ſerve for the bredth near the top, but at 4 inches from the bottom. Let it be two inches leſs, which will be about 17 inches and a half, for the bottom muſt have about 4 inches to Tye up before it can be filled with powder, and more left at top to hold it by and tye it up; then to bring this Cartridge into the proper forme without the uſual manner of a Piece of Wood, ſo as the Shoomaker ſhapes his Shooes, or the Holſter-maker his Holſters; and this may as well be done without, and ſave the trouble of ſuch heavy blocks, that are fit to fill up Store-houſes and load Carriages, and bruiſe Mens Fingers, and break their legs or feet if they fall down upon them; the beſt uſe I can think of for them is to have a large Room all againſt a cold Winter, and free leave to kep a good Fire with them, &c.

Firſt, take 6, 8, or 10 ſheets of Cartridge paper, and cut one ſide thereof ſtreight by the edge of ſome ſtreight Ruler; Then at about 4 inches from that end that you intend for the Top-mark of your bredths, and ſomething leſs diſtance from the bottom, ſet off a ſhorter bredth, as you think convenient, then with a ſharp priming Iron prick a hole through all the ſheets at once, at the places where you mark them

then

then the ſtreight edge of the Paper being laid to thoſe holes, will form the Cartridge of its juſt bignes, as true as if it had been Rowled on a Former. But note this as you have occaſion, that ſide of the Paper that is not cut even muſt have the holes in it, and when you go to fold it, lay it on a Table right before you, with the ſtreight ſide towards you which your Paſte muſt be ſpread upon, if you paſte them, then as the Paper lieth flat, turn part of the further ſide upward, ſo that the holes may fall about one inch nearer you, than the folded Chreſt; Then turn up the ſtreight ſide next you, and ſo that it may touch both the holes, then Chreſt down both the ſides, and ſtroke down the ſtreight edge if it be paſted, and that will be done wit, while it be dry, you may lay the Paſte on ſveral papers at one time, laying one upon the top of the other, and drawing every one an inch or leſs back, as they may lie like ſteps; then with a large broad Knife take up ſome paſte, and ſpread on the Edges as lie like ſteps. It will be moſt convenient to fold down all the ſides that have the holes in firſt, for then the paper will not lie ſo broad, and be more convenient to uſe. But if you make Cartridges with Canvaſs, as uſually they do for all Guns bigger then a demi-Culverin, for a ſheet of paper will not be big enough for any bigger Gun.

Gun. Then you muſt cut your Canvaſs large enough to allow turning down or folding for the Seam, which muſt be half an inch or more, for each ſide; then fold down one ſide as ſtreight as you can, and then mark off your bredth for the top and bottom, as before directed. Mark it at both places with ſome black Lead, Pencil or Marking-ſtone, and with a ſtreight Ruler draw a Line from Mark to Mark the whole length of the Canvaſs; and if you draw a Line on both ſides, it will be the more exact; and then turn down the Canvaſs to both the lines, then with a Needle and Thread cloſe them together, which will be eaſier Work then to make them upon a Former, then with your Finger gather them together in as ſmall Gathers as conveniently you can: then with ſome Twine or good Pack-thread Tye them faſt, and when you Tye them it will be convenient to have two pair of hands, one pair to hold, and the other to Tye. When this is done, ſpread upon the end of the Cartridge below the Knot, and ſpreading the bottom of the Cartridge with a Hammer, knock down the Knot flat, and the Work is finiſhed.

And if there ſhould be occaſion for Cartridges, for Drakes or Taper bored Guns, you may find the Diameter of the Bore at the Vent, with a Gage primeing Iron, and the Diameter 6 or

7 Inches,

7 inches forward may be taken with ſome convenient Rammer head, and then you may make a Cartridge to fit it as well as with a Former, as much tapering as you pleaſe; by the Former Rules, and for eaſe and readines I have calculated a Table, which will give you the bredth of the Cartridg to every tenth part of an inch, from 2 inches to 7 inches, and 9 tenth parts of an inch. And alſo give an Account how far one pound of powder will go in the filling of any one of them.

A TABLE for the Fitting of all ſorts of Cartridges; the Explanation whereof take as followeth.

This Table hereunto annexed, to lie open at the reading or uſing thereof, as are all the reſt, and hath two parts; the firſt and uppermoſt part hath 11 Columns, and ſo hath the ſecond part. The firſt Columns in both of them to the left hand are little Columns, the uppermoſt Figure is (2). and ſo downward ending with (7), which are inches: the ten other Columns are marked at the head with 0. 1. 2. 3. 4. 5. 6. 7. 8. 9. which denoteth the tenth part of every inch in the little columns, and the Figures in the other columns are in the upper part, the bredths of the Cartridges to every inch and tenths

The Bredth of the Cartridg to every

Inches	0	1	2	3	4
2	06::29	05::69	06::91	07::23	07::5
3	09::43	09::74	10::06	10::37	10::6
4	12::75	12::89	13::20	13::51	13::8
5	15::71	16::03	16::34	16::66	16::9
6	18::86	19::17	19::49	19::80	20::1
7	22::00	22::21	22::63	22::94	23::2

The Length of the Cartridge t

	0	1	2	3	4
2	9::889	8::970	8::173	7::471	6::86
3	4::395	4::117	3::863	3::641	3::43
4	2::473	2::353	2::243	2::141	2::04
5	1::582	1::522	1::463	1::408	1::35
6	1::099	1::063	1::629	0::996	0::96
7	0::806	0::785	0::763	0::742	0::72

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every 10th part of an inch in the Diameter.

4	5	6	7	8	9
07::54	07::86	08::17	08::49	08::80	09::11
10::69	11::00	11::31	11::63	11::94	12::26
13::83	14::14	14::46	14::77	15::09	15::40
16::97	17::29	17::60	17::91	18::23	18::54
20::11	20::43	20::74	21::06	21::37	21::69
23::26	23::57	23::89	24::00	24::51	24::83

dge that one Pound of Powder will hold.

4	5	6	7	8	9
6::868	6::330	5::852	5::427	5::046	4::704
3::432	3::229	5::053	2::890	2::740	2::601
2::044	1::954	1::870	1::791	1::717	1::648
1::357	1::308	1::258	1::218	1::175	1::137
0::966	0::930	0::908	0::881	0::855	0::831
0::722	0::703	0::685	0::667	0::650	0::634

tenths of an inch, and in the lower part, the length that one pound of powder will reach in any Cartridge, at any Diameter found in the little column, and under the tenth part at the head of the Table.

The Uſe of the Table for all ſorts of Cartridges, is this,

Suppoſe I would know the bredth of a Cartridge, whoſe Diameter is 4 inches: Then looking in the upper Table in the little column for 4, and againſt it under 0, at the head, I find 12.75, which informs me, that the bredth of ſuch a Cartridge muſt be 12 inches, and 7 tenth parts, and the half of a tenth part.

Then look for 4 in the lower Table, and againſt it is 2,473, which ſheweth that one pound of powder will fill that Cartridge, 2 inches, 4 tenth parts of an inch, and almoſt three quarters of one tenth part of an inch, which wanteth about one quarter of a tenth of being 2 inches and a half; and ſo far one pound of powder will reach.

Example.

EXAMPLE VII.

Now if 6 pounds of Powder be allowed to Load that Gun, then multiply 2:473 by 6 the weight of the powder, and cut off the 3 Fractions, and the product will ſtand thus, 14:838, which ſheweth, that the powder in the Cartridge will reach 14 inches, 8 tenths and a third part of a tenth, which differeth very little from the firſt Example; by Calculation.

EXAMPLE VIII.

If the Diameter given be 6 inches, and 3 tenth parts of an inch, look in the little Column of the upper part of the Table, and in the ſame Line under 3 at the Head of the Table, I finde 19:80 for the bredth of the Cartridg, which is 19 inches, and 8 tenth parts of an inch.

Then look for 6 in the Little Column of the lower part, and under 3 I finde 0:996, which is leſs then one inch by 4 parts of 1000, and ſo far one pound of powder will reach in that Cartridge.

Then let the Allowance be 14 pounds and a half of powder, by which you muſt multiply the former found Number, (*viz.*) 0:996, and the product is 14:442, ſo the powder in the Cartridge

ridge will be 14 inches 4 tenths, and almoſt a half long, which very well agreeth with the third Example, by Calculation.

EXAMPLE IX.

The Diameter 5 inches and 1 tenth, in the upper part of the Table giveth the bredth of the Cartridge to be 16 inches and 3 tenths.

Then in the lower part of the Table at 5 and 1 tenth, I finde 1,522, for the length that one pound will reach in that Cartridge.

Then let the Allowance of Powder be eight pounds and one quarter, which in Decimals will ſtand thus 8,25, which muſt be multiplied by 1,522. Now here you may ſee that there is 5 Fractions, and ſo many muſt be cut off, and the product will ſtand thus, 12:55650 which is 12 inches and about a half for the length of the Powder in the Cartridge, near the fifth Example, by Calculation.

Having gained the Diameter, this little Table furniſheth you with the Circumference, the bredth of the Cartridge, the quantity of the length of the Cartridge that one pound of Powder will fill; ſo with one Multiplication of the weight of the Powder you have the length of the Cartridge filled.

But you muſt obſerve this Caution, the bot-

tom of all Cartridges that are tyed will not have a flat bottom, and will therefore make the Cartridges longer then this Rule will allow of, and indeed longer then they would if they had a bottom cut round and ſowed in. And in ſuch Cartridges theſe Rules will well enough agree, and for knotted Cartridges, the Gunner muſt conſider to allow for, either in the Powder or Meaſuring of them.

EXAMPLE X.

How to fit a Cartridge for a Taper Bored Gun, without a Former.

Suppoſe the Diameter at the Vent to be 2 inches and one tenth part, and the Diameter at 8 inches from the Vent to be 2 inches and 3 tenths. Enter the upper part of the Table and take out the Numbers anſwering to them, both againſt 2:1 is 6:60. And that muſt be the breadth at the bottom, then take out 2:3 and againſt that is 7:23,& that muſt be the bredth at 8 inches. From the other bredth, then by theſe two Marks with a Ruler draw a Line 12 inches long, or more, that you may be ſure to have length enough for any allowance of Powder.

Then enter the lower Table and take out the

the Numbers anſwering to both the Diameters at 2:1 is, 8:970, at 2:3 is 7:471, both added together makes 16:741 the half thereof is 8:370. And ſo far one pound of Powder will reach in that Cartridge.

Now if the allowance be one pound and a half, then you muſt go four inches further, and there the Diameter will be one tenth more, for 8 inches from the Vent, differs 2 tenths, then and 12 the difference muſt be 3 tenth parts, then the bigger Diameter will be 2 inches and 4 tenth parts; then you muſt take that out of the Table for Powder at 2:4 is 6:868, which added to the leſſer, makes 15:834, the half is 7:917, and ſo far one pound of Powder will fill ſuch a Cartridge, when the Area at each end are equated and made equal to a Cylinder, then Multiply 7:917 by 1,5, which is the Decimal for one pound and a half, and the product is 11:9755, and then the Cartridge will be very neer 12 inches long. I have been larger then ordinary in this Example, that you may underſtand me the better. But I ſhall be ſhorter in the next.

EXAMPLE XI.

Let the Diameter at Vent be 3 inches and 2 tenths, and 12 inches forwards, 3 inches and 9 tenths, find the bredth of the Cartridge as be-

fore, the bottom bredth, 10:06, the top bredth 12:26. Now let the quantity of Powder be 3 pounds and a half, then find the length of the Cartridge at 3:9 is 2:601 at 3:2 is 3:863. Add them, and take the half which is 3:232, which Multiplied by 3 pounds and a half, produceth 11:3120 which is 11 inches, and a little more then three tenth parts for the length of the Cartridge.

SECT. VII.

How to find the Diameter of any part of the Bore of the Gun, if the inſides of the Bore be ſtreight Lines, by having the Diameter at Vent and Muzle.

To work this, you muſt have the length of the Bore, the Diameter of the Muzle, and the Diameter of the Vent given, or otherwiſe you muſt take them, then take the difference between the two Diameters, and turn it into tenths of an inch, and when ſo done, divide that difference by the length of the Gun within the Bore, and the Quotient will give you a Number of Tenths to be added to the Diameter at the Vent, which will be the Diameter at one

Foot

The half Bredth of the Cartridge.	[illegible]
The Bredth of the Cartridge.	[illegible]
The Length of the Cartridge.	[illegible]
Weight of the Powder.	[illegible]
Weight of the [illegible]	[illegible]

Names of Ordnance.	Height of the Bore of the Peece.	Diameter of the Shot.	Weight of the Shot.	Weight of the Powder.
F. net:	02:07	1:920	01:00	01:0
F:	02:64	2:524	02:0¼	01:
3;	02:97	2:777	03:00	02:0
M:	03:30	3:057	04:00	03:0
S:	03:60	3:347	05: ¼	04.0
6:	03:74	3:500	06:00	04:
D:C	04:25	4.007	09.00	07.0
12	04.73	4:409	12.00	08.0
W:C	05:3	5:04	18.00	10.0
24	05.90	5.554	24:00	11.0
D:C:	06.30	6.114	32.00	15.0
B:C:	07.00	6.695	42.00	18.0
W:C:	08.00	7.663	63.00	23.0

Weight of the Powder.	The Length of the Cartridge.	The Bredth of the Cartridge.	The half Bredth of the Cartridge.
01:00	10:96	06:29	03:14
01: ¼	07:32	07:86	03:98
02:00	10:09	09:11	04:55
03:00	12:35	10:06	05:03
04.00	13:73	11:00	05:50
04: ¼	12:97	11:63	05:81
07.00	16.47	13.00	06.60
08.00	15.63	14.46	07.23
10.00	15.22	16.34	08.17
11.00	13.84	17.91	08.95
15.00	15.44	19.49	09.74
18.00	15.39	21.69	10.89
23.00	13.95	24.51	12.24

ge 148.

Foot from the Vent, and the half of added to the Diameter at the Vent, is the Diameter 6 inches from the Vent and the Quotient, and half of it added to the Vent will be the Diameter 18 inches from the Vent, and ſo further if you pleaſe; but by reaſon there are no Guns that carry a ſingle Shot that are thus made, this will be of little uſe in this caſe, but it may ſerve for ſome other uſe; therefore I ſhall ſet down a General Rule for to find the Diameter at any length. As the length of the Gun is to the difference o the Diameters, ſo is any other length to the part of the difference, which muſt be added to the Diameter at Vent.

SECT. VIII.

A TABLE of Gunnery fitted to all the uſual ſorts of Guns, the heighth of the Bore, the weight of the Shot and Powder are taken out of the Right Worſhipful Sir Jonas Moores Fortifications, *and the reſt by me Calculated.*

This Table hath eight Columns, the firſt to the left hand are the names of Ordnance; the ſecond, the heighth of the Bore; the third the Diameter of the Shot; the fourth, the weight of the Shot; the fifth, the weight of the Powder,

and the ſixth, the length of the Cartridge, when fill'd with ſo much Powder; the ſeventh is the bredth of the Cartridge, when laid over; the laſt is the half bredth of the Cartridge, or the whole bredth when the Cartridge is foulded. The name of every Column is writ at the head, as will plainly appear by an Example or 2, the Table is faſtened to the edge of the Book.

EXAMPLE I.

The Uſe thereof is this. Suppoſe the Gun be a *S*akear marked in the firſt Column with S, and in the ſame Line towards the Right hand in the ſecond Column is 3:60. By the Title at the top, it tells you that the heighth of the Bore of that Gun is 3 inches and 6 tenth parts of an inch; and in the next Column you will find 3:347 for the Diameter of the Shot; and in the fourth Column, is 5:$\frac{1}{4}$ which is the weight of the Shot 5 pounds and a quarter; and the fifth Column is the Weight of the Powder allowed for one Charge for ſervice (*viz*) four pounds; and the ſixth, telleth how long a Cartridge muſt be to hold 4 pounds of powder, as you may ſee 13 inches and a little above 7 tenth parts; the ſeventh, is the bredth of the Cartridge when laid open (*viz*) 11 inches; and the laſt Column is the half bredth of the Cartridge

tridge, or the bredth when the Cartridge is foulded, and ſowed or paſted, as you may ſee it is the half of 11 which is five and a half.

EXAMPLE II.

A Demy-Culverin marked in the firſt Column with D. C. and in the next to the right hand is 4:25 for the heighth of the Bore; and then, 4:007 for the Diameter of the Shot, and in the fourth 09:00 the weight of the Shot; the fifth 7:00 the weight of the Powder; the ſixth is 16:47 the length of the Cartridge, the ſeventh is 13:20 the bredth of the Cartridge, and the eighth and laſt is the half bredth of the Cartridge, which will be very uſeful for the ſorting of Cartridges in any of his Majeſties Stores, with the help of a Rule divided into inches and the tenth parts of an inch, the bredth being meaſured in inches and tenths, by looking on the Table you may find what Gun that Cartridge is for, As if the half bredth were 7 inches and a little more then two tenth parts, in the laſt Column you find 7-23, and againſt it in the firſt Column is 12, which informs you that the Cartridge is for 12 pounds, and almoſt 9 inches ſerveth a 24 pownder, and a little more then 4 and a half fits a 3 Pownder, and ſo of all the reſt.

SECT. IX.

Having the Weight of an Iron Shot to find the Diameter.

This may be found by the Rule of Proportion, thus, as 140 is to the Cube of 10, ſo is the weight of the Shot to the Cube of its Diameter: The Rule thereof will be the Diameter deſired: Or thus,

As 9 pounds weight is to the Cube of 4 inches Diameter, ſo is any other weight to the Cube of the Diameter thereon to be belonging, the Cube Rule being extracted is the Diameter deſired.

There will be but little occaſion for either of theſe Rules, by reaſon the Diameter will eaſily enough be had without this trouble, either by the Gauging or Sizing Ring or Callipars; and if you pleaſe, if the Diameter of any Shot may be had by ſuch a Table that is made for the Diſparting of a Gun, without doubling the Ribbon or Tape, or with doubleing it eaſier: For if you uſe doubling it and meaſure the half-Girt of the Shot on a Rule, it will be but half the Diameter: But if you meaſure the whole Girt, the Rule will give you the inch and tenths for the whole Diameter,

ter, with entring the Table by Inſpection; as will more fully appear by this.

EXAMPLE I.

Suppoſe I girt a Shot that is about 6 pounds weight, and the Circumference (when Meaſured) I find to be 11 inches and 2 tenth parts; I look in the Diſparting Table for 11 in the little Column, and under 2 at head, I finde 3,519 the Diameter, as near as a pair of Callipars will take it, (*viz.*) three inches, and 519 parts of 1000.

EXAMPLE II.

Let the Girt or Circumference (Meaſured on a Rule) of ſome Shot, be 21 inches and ſix tenths; the half of that (by reaſon that exceeds my Table) is 10:8, for which Number I look in the Table as before, and I find 3:393, which is half the Diameter, and that doubled is 6:786 for the whole Diameter, the ſame may be done by doubling the Ribbon or Tape, and meaſuring it on a Rule, it will give you 10 inches and 8 tenths; you may have this Table projected on a Rule, or any other Inſtrument made, for taking the Heights or Diſtances, or the Plot of any Citadel, or for any other, by

Mr.

Mr. *Walter Hayes* at the *Popes*-head in Moor-Fields, or by Mr. *John Brown* at the Sphere and Sun-Dial in the *Minories* at reaſonable Rates.

And to ſatisfie any ones Curioſity, I have here Calculated a Table to every pound weight of Shot, beginning at 1 and ending at 64 pounds, which I think to be as big and as little as will be of any uſe. This Table is Fixed to the Margent as the others are.

Explanation of the Table.

This Table hath four Columns; The firſt and third are pounds; the ſecond and fourth are the Diameters anſwering to each pound, to the 1000th part of an inch.

Uſe of this Table.

Having the Number of pounds that any Iron Shot doth weigh; you may finde what Gun it will fit, and by it you may make a Cartridge for ſuch a Gun without ſeeing of the Gun: If it be true Bored, and not Taper at the Chamber; And it alſo is a hard Queſtion to ask an ordinary Gunner, what is the Diameter of a Shot that weigheth 64 pounds or any other ſhot, as 50 pounds weight, that ſhot being

A Table of Shots Diameter.

01	1.926	33	6.177
02	2.427	34	6.239
03	2.777	35	6.300
04	3.057	36	6.359
05	3.294	37	6.417
06	3.500	38	6.475
07	3.684	39	6.531
08	3.852	40	6.586
09	4.007	41	6.641
10	4.149	42	6.695
11	4.283	43	6.747
12	4.409	44	6.799
13	4.528	45	6.850
14	4.642	46	6.900
15	4.750	47	6.950
16	4.849	48	6.999
17	4.948	49	7.048
18	5.047	50	7.095
19	5.139	51	7.142
20	5.228	52	7.188
21	5.313	53	7.234
22	5.395	54	7.278
23	5.477	55	7.324
24	5.554	56	7.368
25	5.632	57	7.412
26	5.705	58	7.454
27	5.778	59	7.498
28	5.849	60	7.539
29	5.930	61	7.581
30	5.984	62	7.640
31	6.050	63	7.663
32	6.114	64	7.704

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being not near any of our common Guns. It will be hard to anſwer by the Cube-roots, and not eaſie by Solids.

SECT. X.

How you may Elevate a Piece of Cannon to any convenient degree of Mounture by a Quadrant.

FOR to do this, you are to have a large Quadrant faſtned to a Beam at a right Angle, with 0 degrees of Mounture; Then in the Centre of the Quadrant, you muſt Fix a ſmall Line with as weighty a Plummet as the Line will bear; For the ſmaller the Line, and the heavier the Plummet, the truer you may diſcern the degree, and part thereof you would have the Piece elevated to; Or in ſtead of a Line and Plummet, you may have an Index of Braſs, heavy loaden at the lower end with a very ſmall Point at the bottom, to ſhew the Degree and part thereof that the Gun is Mounted at, The bigneſs of the Quadrant ought to be a Foot or more, and made with braſs, and the Beam 3 or 4 Foot long, and weighty, that it may lie ſtedfaſt in the Bore of the Piece.

It

It will be convenient to have the Quadrant ſo fitted to the Beam, that either ſide may be put forward for the taking the degrees of depreſſion, if you ſhould have occaſion.

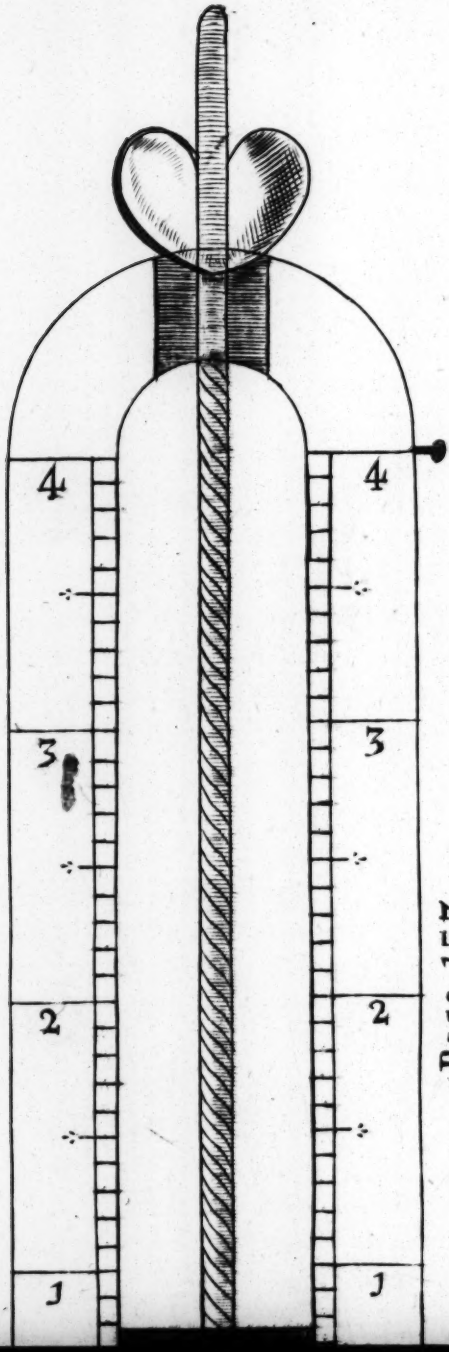
I ſhall ſay nothing of the Deſcription of the Quadrant, for it matters not in what form it is ſo it be well divided, Diagonally into every tenth part of a degree, without any other Diviſions, not as they commonly do divide them, into degrees and half degrees, but only whole degrees and tenth parts, for the halfes cauſe miſtakes.

The Uſe of a Quadrant in the Mounting of a Peece.

The Quadrant being faſtned to the Beam with a Line and Plummet, or a Loaded Index, then put the Beam of the Quadrant into the Mouth of the Gun, with the Index or Plummet hanging looſe, that it do not bear on the Line of the Inſtrument, then lower the Metal at the Breech, until you finde the Line or Index to cut that degree you would have the Gun Mounted to.

I ſhall ſay no more of the Quadrant, but ſhew you another way of Mounting of a Gun, to any conyenient Elevation by a Sight Rule.

Deſcri-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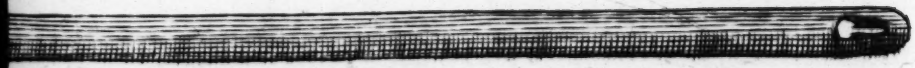


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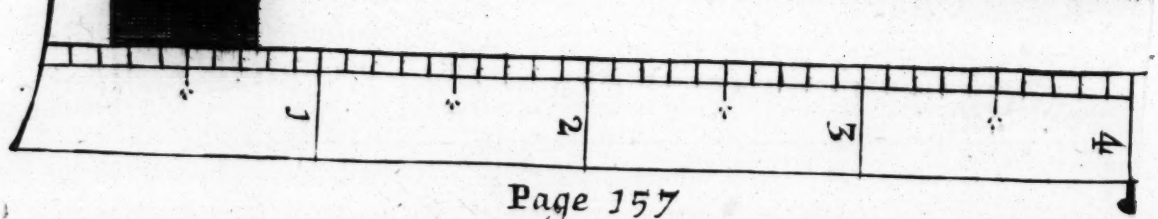

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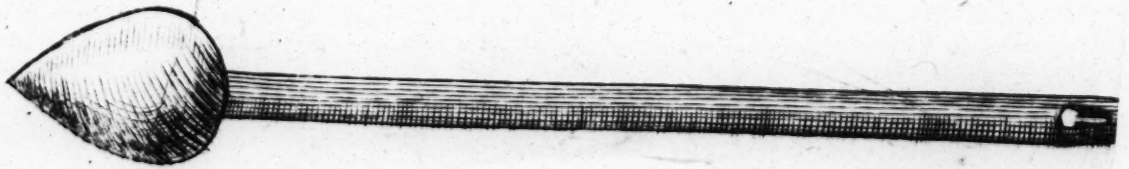


Deſcription of the Sight-Rule.

This Rule had need to be 3 Foot long, with a large Slit in the middle for a Slider to move in, with a little hole in it to look through, and let it be ſlit quite through at the bottom, and a piece of braſs faſtned over it; and at the top it may be left whole for half an inch from the end or more; and a Nut let into the head for a Screw to paſs through down to the Slider; and on the top of the Rule, a Screw-Nut to go upon the Screw, to raiſe the Slider to what height you pleaſe, for in ſuch a length you may have the Slider go too ſtiff or too eaſie without a Screw: On both ſides of the Slit, the Rule muſt be divided into two Foot, and every Foot into 10 parts, and every one of thoſe parts into 10 more: ſo then every Foot will be 100 parts.

Then through the Centre of the little hole, let there be a ſmall Line drawn Parallel to the Horizon, which will ſhew at what height the Sight or Hole ſtandeth at from the Baſe-ring of the Gun; You muſt alſo have an Index to hang on the edge of this Rule, loaded at the bottom, and under it a ſmall Point Perpendicular to the Pin the Index hangeth on; to ſhew when the Rule ſtandeth upright: a

ſhort

ſhort Pattern of the Rule and Index is hereunto annexed.

The Uſe of the Sight-Rule.

Firſt, You muſt truly Diſpart the Metal of the Gun, and ſet up the Diſpart Perpendicular; then you are to meaſure the length from the Baſe-ring of the Piece to the Diſpart; Then to find what Number of parts of this Rule will anſwer to what Degrees of Mounture you pleaſe, you muſt Calculate by the Logarithms, and Artificial Signs, which are but two Numbers to add together, for the Sight in the ſlider will alwayes be a right Angle to the ſtreight Line betwixt the Baſe-ring and the Diſpart.

How to find the Sights diſtant from the Baſe-ring at any Degree, or part of a Degree of an Elevation.

The proportion is thus. As the Radius, or Sign of 90 Degrees, is to the Logarithm of the Guns length, ſo is the Sign of Elevation, to the Logarithm of the Diſtance of the Sight in the Rule to the Baſe ring of the Piece

EXAM-

EXAMPLE I.

The length of the Gun from the Baſe-ring to the Diſpart 8 Foot and 7 tenth parts.

Degrees of Mounture 2 Degrees and 6 tenth parts of a Degree.

	f
Logarithm of 8:7	0 9 3 9 5 2.
Sign of 2:6	8 6 5 6 7 0.
Logarithm of 3:95	9 5 9 6 2 2.

Which is 3 tenth parts of a Foot, and 9 tenth parts and a half of a Decimal inch. You muſt underſtand that there is but ten ſuch inches in one Foot, and in the Sight Rule I ſhall uſe them, by reaſon the Rule is directed ſo to be made.

It is like ſome may be at a little loſs with this Logarithm that ſtandeth againſt 3:95. becauſe there will be no ſuch found; and indeed it is an imperfect Logarithm; it being the Logarithm of leſs then (one), but you may help your ſelf thus; Take the length of the Gun in Decimal inches, which is 87 as a whole Number, and not as 8 Foot and 7 tenth parts, and then your work will ſtand thus.

Loga-

Logarithm of 87, is —— —— 193952
The Sine of 2 : 6 —— —— 865670
Logarithm of 3 : 95-- —— 059622

So by this you may underſtand, that if your Gun be Mounted two degrees, and 6 tenth parts of a degree, the ſight muſt ſtand 3 inches and 95 parts of an inch from the baſe-ring.

EXAMPLE II.

Length of the Gun 9 : 8 —— —— 199123.
Degrees of Elevation 7 : 8 —— 913263.
Logarithm of 1 : 330 the heighth -- 112386.

In this Example the Sight in the Rule will ſtand 1 Foot, 3 inches and three tenth parts of an inch from the Baſe-ring of the Piece.

Then having ſet your Diſpart upright, you muſt alſo ſet the Sight Rule upright by its Index, then let the Metal of the Breech of the Gun be Loured, till through the Sight being ſet at its proper heighth, you can ſee the Diſpart and the Mark in the ſtreight Line, then is the Gun truly Elevated to the Degrees and parts deſired, and thus when you have brought the Gun ſo to paſs, then try with your Quadrant whether it agreeth with the Sight unto which you work true, the difference will be very

very little; and the trueſt will be the Sight-Rule, except you have a Quadrant that will anſwer to as large a Diameter as the Sight-Rule doth; for the Radius of the Work of the Sight Rule is always the Diſtance from the Sight to the Diſpart, which in ſome Guns will be 10 or 11 Foot, and a Quadrant of that bigneſs will be very Coſtly and Cumberſom to uſe. It is the Opinion of all Perſons, that the larger the Inſtrument for Obſervation, the truer it is; then the Sight-Rule muſt be truer then the Quadrant.

EXAMPLE. III.

The length of a Gun 11:03 —— 105308
Degrees of Elevation 14:04 —— 93956
Logarithm of the Sights 2:8 1 diſt. —— 04874

Here I find that a Gun whoſe length from the Baſe-ring is 11 Foot and three tenths, and Elevated 14 Degrees, and 4 tenth parts of a Degree (which is 24 Minutes) the Sight o the Rule will be 2 Foot 8 inches and 1 tenth part of an inch high, from the Baſe-ring of the Gun to the Sight, to mount the Diſpart ſo high.

And if any Gunner hath a Sight-Rule other ways divided, as into common inches, of 12 in one Foot, and every one of them inches divi-

ded into ten parts, then all that you have to alter from the former work, is to take the length of the Gun into inches, and if any odd remain ſet it down in tenths of an inch, as I ſhall make plain by an example or two.

EXAMPLE IV.

Suppoſe the ſame length as in the firſt Example, (*viz.*) 8 Foot and 7 tenths; Multiply 12 by 8, produceth 96 inches, then to reduce the 7 tenths into common inches; Multiply 12 by 7 gives 8.4, which is 8 inches and 4 tenths of an inch, then add 8 to 96, and the ſum is 104, the length of the Gun in inches, to it joyn your 4 tenth parts of an inch, and the Number will ſtand thus-- 104:4.

Logarithm of 104:4	--201870
Sine of Elevation-2:6.	--865670
Logar. Diſtance. 4:74	--067540

Then by theſe common inches the diſtance of the Sight in the Slider is 4 inches, and 7 tenths of an inch, and about 1 third part of a tenth of an inch or a little more, and by the firſt Example it was 3:95, which multiplied by 12 produceth 4:740, which is 4 inches and 7 tenths, and betwixt a third and a half, as the laſt Example is. There

There may fall in ſome Gunners hands a Sight-Rule in 12s. of a Foot and 8s. of an inch, which will not be amiſs in this place to clear that alſo, and ſhew the Reader how he may help himſelf in ſuch a caſe, the eaſieſt way to do this is by the Golden Rule, thus, If 8 parts of an inch give 10 parts, 4 parts will give 5, but none of the other will come even, but near enough the truth; for a tenth part of an inch in the length of a Gun is not conſiderable. Here needs no Example of this, for it will be the ſame with the former, only clearing the Fraction at the laſt, which is 74 multiplied by 8, whereof cometh 592. Cut off the two laſt Figures to the right hand, and there will remain to the left hand 5 and 92 parts of 100, which in this caſe may well go for 6 Eights of an inch, ſo the Diſtance of the Sight from the Baſe-ring is 4 inches, and ſo near 6 Eights of an inch by the common Meaſure of Inches and Eights.

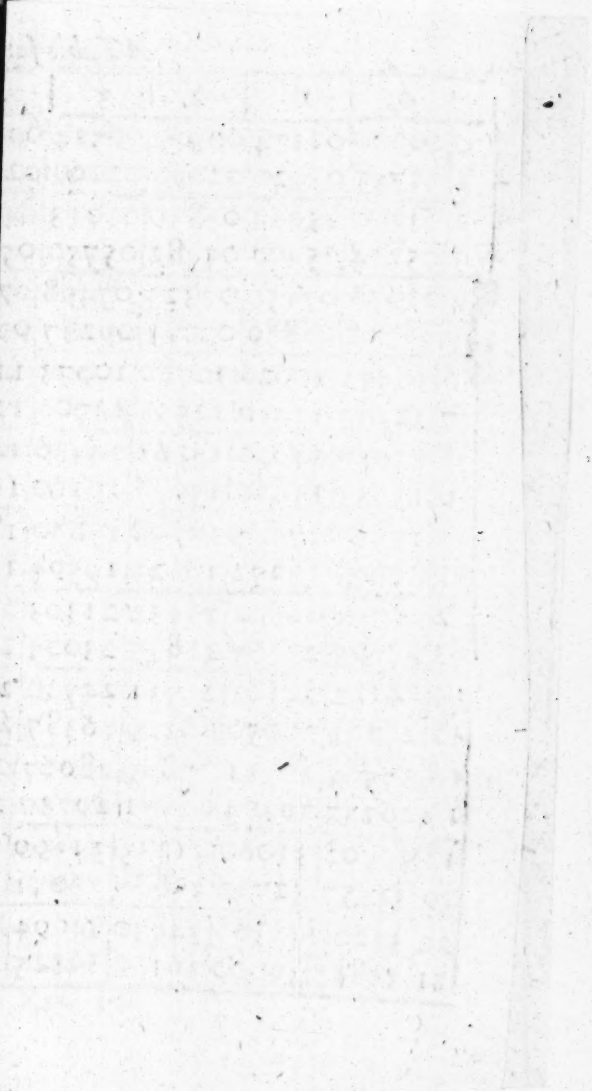
And by reaſon that all Perſons do not know how to uſe the Signes and Logarithmes, I have made a Table whereby you may do it by Multiplication.

The Deſcription of the Table.

The Table hath Eleven Columns, the firſt of them to the left hand, is a little one beginning with 0. 1, 2, 3, and ſo downward to 21 which are Degrees, and at the head of the other ten Columns is ſet 0. 1, 2, 3, and ſo forwards to the right hand to 9, which are the tenth parts of the Degrees in the little Column on the left hand, the five Figures in the 10 Columns are Numbers to be Multiplied by the length of any Gun that you would Elevate to any Degrees, and tenth parts of a Degree of Mounture.

The Uſe of the Table.

Firſt, Having Diſparted the Gun and ſet up the Diſpart Perpendicular on the Muzle-ring of the piece of Cannon, then you muſt reſolve what Elevation you will lay her at, then find the Degrees in the little Column on the left hand, and the parts of the Degrees, under the tenth parts at the head of this Table, at the Angle of Meeting you have a Number of 5 Figures, by which you muſt Multiply the length of the Gun, and cut off four Figures to the right hand, and what remains to the left, if two Figures remain, the firſt to the right hand are Feet, and the



	0	1	2	3	4
0	00000	00174	00349	00524	00698
1	01745	01920	02094	02269	02443
2	03490	03664	03839	04013	04188
3	05234	05408	05582	05756	05931
4	06976	07150	07324	07498	07672
5	08716	08889	09063	09237	09411
6	10453	10626	10780	10973	11147
7	12187	12360	12533	12706	12880
8	13917	14090	14263	14436	14608
9	15643	15816	15988	16160	16333
10	17365	17537	17708	17880	18052
11	19081	19252	19423	19595	19766
12	20791	20962	21132	21303	21474
13	22495	22665	22835	23005	23175
14	24192	24362	24531	24700	24869
15	25882	26050	26219	26387	26556
16	27564	27731	27899	28067	28234
17	29237	29404	29571	29737	29904
18	30902	31060	31233	31399	31565
19	32557	32722	32887	33051	33216
20	34202	34366	34530	34694	34857
21	35837	36000	36162	36325	36488

4	5	6	7	8	9
00698	00873	01047	01222	01396	01571
02443	02618	02792	02967	03141	03316
04188	04362	04536	04711	04885	05059
05931	06105	06279	06453	06627	06801
07672	07846	08020	08194	08368	08542
09411	09585	09758	09932	10106	10279
11147	11320	11494	11667	11840	12014
12880	13053	13226	13399	13572	13744
14608	14781	14954	15120	15299	15471
16333	16505	16677	16849	17021	17103
18052	18224	18395	18567	18738	18910
19766	19937	20108	20279	20450	20620
21474	21644	21814	21985	22155	22325
23175	23245	23514	23684	23853	24028
24869	25038	25207	25376	25545	25713
26556	26724	26892	27060	27228	27396
28234	28401	28569	28736	28903	29070
29904	30071	30237	30403	30570	30736
31565	31730	31896	32061	32227	32392
33216	33381	33545	33710	33874	34038
34857	35021	35184	35375	35511	35674
36488	36650	36812	37002	37110	37299

the ſecond the Decimal inches of a Foot, and the Fraction cut off will be a Decimal part of an inch, as you may better underſtand by the Examples following.

EXAMPLE V.

Let the Gun mounted be 8 foot, and 7 tenth parts of a Foot long, and to be Elevated two Degrees and ſix tenth parts of a Degree; Then look into the little Column on the left hand for 2 Degrees, then guiding my eye till I come under 6 at the head, and in the ſame line that I find the (2) at the Angle of Meeting I find 04336, which I muſt Multiply by the length of the Gun (*viz.*) 8:7 and the Product is 3,9,4362, then cut off 4 Figures for the Tabular Number, and one for the Fraction of 7 tenths in the length of the Gun, and then there will remain but 3; to the left hand which is 3 tenth parts of a Foot, and the other Figure cut off, is the 9 tenth parts of an inch and about half a tenth; ſo the height in the Slider will be the diſtance from the Baſe ring of the Piece 3946 parts of 10000 of a Foot, which you may have in common inches and eighths of an inch, by Multiplying it by 12, and cutting off 4 Figures, and what remains are inches, then Multiply the 4 Figures cut off, by 8; and cut off 4 Figures

more, and what remains to the left hand are eighths of an inch, as thus, 3946 multiplied by 12 produceth 47352, then cut off the 4 laſt, and there will remain to the left hand. 4; which are 4 inches, or 4 twelve parts of a Foot, then multiply 7352, which are the 4 Figures cut off by 8, and the product is 58816, then cut off 4 Figures as before, and the remainder to the left hand is (5), which is 5 eighths of an inch, but by reaſon the two firſt Figures that are cut off are 88, you may very well Accompt the 5 to be 6 Eights, for it doth not want half a quarter of 6 Eights, and this way you may reduce any Decimal into any other meaſure at pleaſure, and make any Diviſions on the Sight-Rule to ſerve your turn.

EXAMPLE VI.

If a Gun were to be Elevated 7 degrees, and 8 tenth parts of a degree, and the length of the Gun 9 Foot and 8 tenths of a Foot, and I would know the height or diſtance of the ſight from the Baſe-ring of the Piece. Then I look in the firſt Column to the left hand for 7 Degrees, and guiding my eye along the ſame Line, till I come under 8 at the head of the Table, and at the Angle of Meeting I find 13572, which being multiplied by the length

of

of the Gun makes 1,3,30056, which is 1 Foot 3 inches, and 3 tenths of an inch, as it was found by the ſecond Example, by Trigonometry; and this you may reduce into common Inches and Eights, as you did by the former Example at pleaſure, and it will be found to be 15 Inches and 7 Eights, and about half an Eight, and that will be the Diſtance of the Sight and the Baſe-ring in common meaſure.

EXAMPLE VII.

Suppoſe you were to elevate a Piece of Cannon 14 degrees, and 4 tenth parts of a degree, and the length of that Piece be 11 Foot and 3 tenth parts of a Foot. I look in the firſt little Column for 14 degrees, and under 4 at the head, I find in the Angle of Meeting 24869, which being multiplied by 11:3, the product is 2:8:1:0197, which is 2 Foot, eight inches, and 1 tenth of an inch, the reſt of the Figures are of no uſe in this caſe, if this be reduced as before into common meaſure, it will be 2 Foot, 9 Inches, 5 Eights, and 3 quarters of 1 Eighth. And ſo much is the height of the ſight in the Slider of the Sight-Rule from the Baſe-ring of the Piece.

But if you take the length of the Piece in inches, then the height of the Sight-Rule will be produced in inches, and a Decimal Fraction of an inch, as in this laſt Example. The Guns length in inches is 135 inches and 6 tenths of an inch, which being Multipli'd by 24869 the Tabular Number, produceth 33722364 which is 33 inches and 7 tenth parts of an inch, and almoſt one quarter of a tenth.

EXAMPLE VIII.

Having the length of a Gun in inches and tenth parts of an inch, as in the fourth Example, the length there is 104 inches and 4 tenth parts of an inch, and the Degrees of Elevation 2 Degrees, and ſix tenth parts of a Degree; I look in the little Column of the Table for two Degrees, and in the ſame line under 6 at the head of the Table, I find 04536, which Multipli'd by the length of the Gun 104:4 produceth 4:73:5584. The firſt Figure to the left hand is inches, and the ſecond Figure is the tenth parts of an inch, and the reſt a Decimal Fraction, ſo the Sight in the Rule muſt ſtand 4 inches and 7 tenths and a little more then one third of a tenth, as in the above named Example. So that any one but meanly verſed in Arithmetick, may lay a Gun to what Elevation

on he pleaſeth by this Table Let the Gun be of any length whatſoever, but you muſt always remember that you count the length of the Gun to be but the diſtance from the place where the Sight-Rule ſtandeth, and the top of the Diſpart; for the Angle of the Sight anſwereth to no other diſtance or Guns length but that. A Gun being 15 Foot and a half long, which is in inches 186, and the Degrees of Mounture, 11 Degrees and 4 tenths; the Sight will be diſtant from the Baſe-ring of the Gun, 36 inches 7 tenths, and a little above half a tenth part of an inch.

A TABLE whereby you may find any Acceſſeable diſtance or Altitude within convenient Sight, by one Multiplication and one Angle, taken with a Quadrant, or any other Inſtrument convenient for that purpoſe with Inſtructions how to make the Table to any Degree and Minute of the Quadrant.

How to make the Table.

Firſt, Take the Artificial Tangent of the Degree and Minute that you intend to find the Number for, and caſt away the Radius or firſt Figure thereof; if your Degree be 45; but if more then 45, cut off the two firſt Figures and

and reſerve the reſt of the Number. Then if you would have but 4 Figures in the Table, put a Figure of 3 before your reſerved Number; but if you would have 5 Figures in the Table, then let there be placed before the reſerved Number a Figure of 4, then look that Number among the Logarithmes, and the Number anſwering thereto, is the Tabular Number deſired, anſwering to the ſame Degree and Minute that you took your firſt Tangent for.

Example how to make the Table following.

I would finde the Tabular Number anſwering to 10 degrees and 5 tenths, for which I look the Tangent of 10 Degrees and 30 Minutes, 30 being the half of 60, as 5 is the half of 10, and finde the Tangent to be 9:267967. Then as before directed cut off the firſt Figure which is 9, and put 3 in the room thereof, and then the Number will be thus 3,267967, for which Number I look in the Logarithms, and the neareſt I finde is 3,267172, and the Number anſwering thereto is 1853, the Tabular Number deſired, but in ſtead of placing 3 you may put in 4 to be the firſt Figure of the Logarithm, but then a common Canon of Logarithms will not reach: but this will be true enough for any uſe,

	0	1	2	3	4
0	000000	000015	000035	000052	000070
1	000175	000192	000209	000227	000224
2	000349	000367	000384	000402	000419
3	000524	000542	000559	000577	000594
4	000699	000717	000734	000752	000769
5	000875	000892	000910	000928	000945
6	001051	001069	001086	001104	001122
7	001228	001246	001263	001281	001299
8	001405	001423	001441	001459	001477
9	001584	001602	001620	001638	001655
10	001763	001781	001799	001817	001835
11	001944	001962	001980	001998	002016
12	002126	002144	002162	002180	002199
13	002309	002327	002345	002364	002382
14	002493	002512	002530	002549	002568
15	002679	002698	002717	002736	002754
16	002897	002886	002905	002924	002943
17	003057	003076	003096	003115	003134
18	003349	003269	003285	003307	003327
19	003443	003463	003482	003502	003522
20	003640	003659	003679	003699	003719
21	003839	003859	003879	003899	003919
22	004040	004061	004081	004101	004122
23	004245	004266	004287	004307	004327
24	004452	004473	004494	004515	004536
25	004663	004684	004706	004727	004748
26	004877	004899	004921	004942	004964
27	005095	005117	005139	005161	005184
28	005317	005340	005362	005384	005407
29	005543	005566	005589	005612	005635

	5	6	7	8	9
0	000087	000105	000122	000140	000157
1	000262	000279	000297	000314	000332
2	000437	000454	000472	000489	000507
3	000612	000629	000647	000664	000682
4	000787	000805	000822	000840	000857
5	000963	000981	000998	001016	001033
6	001139	001157	001175	001192	001210
7	001317	001334	001352	001370	001388
8	001495	001512	001530	001548	001566
9	001673	001691	001709	001727	001745
10	001853	001871	001890	001908	001926
11	002035	002053	002071	002089	002107
12	002217	002235	002254	002272	002290
13	002401	002419	002438	002456	002475
14	002586	002605	002623	002642	002661
15	002773	002792	002811	002830	002849
16	002962	002981	003000	003019	003038
17	003153	003172	003191	003211	003230
18	003346	003365	003385	003404	003424
19	003541	003561	003581	003600	003620
20	003739	003759	003779	003799	003819
21	003939	003959	003975	004000	004020
22	004142	004163	004183	004204	004224
23	004348	004369	004390	004411	004431
24	004557	004578	004599	004621	004642
25	004770	004791	004813	004834	004856
26	004986	005008	005029	005051	005073
27	005206	005228	005250	005272	005295
28	005430	005452	005475	005498	005520
29	005658	005681	005704	005727	005750

	0	1	2	3	4
30	005774	005797	005820	005844	005867
31	005909	006032	006056	006080	006104
32	006249	006273	006297	006322	006346
33	006404	006519	006544	006569	006594
34	006745	006771	006796	006822	006847
35	007002	007028	007054	007070	007107
36	007265	007292	007319	007346	007373
37	007536	007563	007590	007618	007646
38	007813	007841	007869	007898	007926
39	008098	008127	008156	008185	008214
40	008391	008421	008451	008481	008511
41	008693	008724	008754	008785	008816
42	009004	009036	009067	009099	009131
43	009325	009358	009391	009424	009457
44	009657	009691	009725	009759	009793
45	010000	010035	010070	010105	010141
46	010355	010392	010128	010464	010501
47	010724	010767	010799	010837	010875
48	011106	011145	011184	011224	011263
49	011504	011544	011585	011626	011667
50	011918	011960	012002	012045	012088
51	012349	012393	012437	012482	012527
52	012799	012846	012892	012938	012985
53	013270	013319	013367	013416	013465
54	013764	013814	013865	013916	013968
55	014281	014335	014388	014442	014496
56	014826	014882	014938	014994	015051
57	015399	015458	015517	015577	015637
58	016003	016066	016128	016191	016255
59	016643	016709	016775	016842	01690

	15	16	17	18	19
30	005890	005914	005938	005961	005985
31	006128	006152	006176	006200	006224
32	006371	006395	006420	006445	006469
33	006619	006644	006669	006694	006720
34	006873	006899	006924	006950	006976
35	007133	007159	007186	007212	007239
36	007400	007427	007454	007481	007508
37	007673	007701	007729	007757	007785
38	007954	007983	008012	008040	008069
39	008243	008273	008302	008332	008361
40	008541	008571	008591	008632	008662
41	008847	008878	008910	008941	008972
42	009163	009195	009228	009260	009293
43	009490	009523	009556	009590	009623
44	009827	009861	009896	009930	009965
45	010177	010212	010247	010283	010318
46	010538	010575	010612	010649	010686
47	010913	010951	010990	011028	011067
48	011303	011343	011383	011423	011463
49	011708	011750	011791	011833	011875
50	012131	012174	012218	012261	012305
51	012572	012617	012662	012708	012753
52	013032	013079	013127	013175	013222
53	013514	013564	013613	013663	013713
54	014019	014071	014124	014176	014229
55	014550	014605	014659	014715	014770
56	015108	015166	015224	015282	015340
57	015697	015757	015818	015880	015941
58	016319	016383	016447	016512	016577
59	016977	017045	017113	017182	017251

	0	1	2	3	4
60	017321	017391	017461	017532	017603
61	018040	018115	018190	018265	018341
62	018807	018887	018967	019047	019128
63	019626	019711	019797	019883	019970
64	020503	020594	020686	020778	020872
65	021445	021543	021642	021742	021842
66	022460	022566	022673	022781	022889
67	023559	023673	023789	023906	024023
68	024751	024876	025002	025129	025257
69	026051	026187	026325	026464	026605
70	027475	027625	027776	027929	028083
71	029042	029208	029375	029544	029714
72	030777	030961	031146	031334	031524
73	032709	032914	033122	033332	033544
74	034874	035105	035339	035576	035816
75	037321	037583	037848	038118	038391
76	040188	040408	040713	041022	041335
77	043315	043662	044015	044373	044737
78	047046	047453	047867	048288	048716
79	051446	051929	052422	052924	053435
80	056713	057297	057894	058502	059124
81	063137	063859	064596	065350	066122
82	071154	072066	073002	073962	074947
83	081445	082636	083863	085126	086427
84	095144	096768	098448	100187	101988
85	114301	116645	119087	121632	124288
86	143007	146685	150557	154638	158946
87	190811	197403	204465	212049	220217
88	286362	301446	318205	336934	358006
89	572900	636564	716150	818464	954893

	5	6	7	8	9
60	017675	017747	017820	017893	017966
61	018418	018495	018572	018650	018728
62	019210	019292	019375	019458	019542
63	020057	020145	020233	020323	020413
64	020965	021060	021155	021251	021348
65	021943	022045	022148	022251	022358
66	022998	023109	024220	023332	023445
67	024262	024262	024383	02 504	024627
68	025386	025517	025649	025782	025916
69	026746	026889	027033	027179	027326
70	028239	028397	028556	028716	028878
71	029887	030061	030237	030415	030595
72	031716	031910	032106	032305	032506
73	033759	033977	034197	034400	034626
74	036059	036305	036554	036806	037062
75	038667	038947	039232	039520	039812
76	041653	041976	042303	042635	0 2672
77	045107	045483	045864	046252	046646
78	049152	049594	050045	050504	050970
79	053955	054486	055026	055578	056140
80	059758	060405	061066	061742	062432
81	066912	067720	068547	069395	070264
82	075958	076996	078062	079158	080285
83	087769	089152	090579	092052	093572
84	103854	105789	107797	109882	112048
85	127062	129962	132996	136174	139507
86	163499	168319	173432	178863	184644
87	229038	238593	248978	260307	272715
88	381885	409175	440662	47739	520805
89	1145891	1432363	1909865	2864819	5729634

Explanation of the foregoing Table.

This Table hath 12 Columns, the firſt Column to the left hand beginneth with 1, 2, 3, and ſo goeth downward to 29, which ſignifieth Degrees, and the Column next unto the little Column is a Decimal Number, anſwering to each whole degree, and the next Column to it is noted at top with a figure of 1. which ſignifieth one tenth part of a Degree, and the third Column hath a figure of 2 at the Top, which ſignifieth two tenth parts of a degree, and ſo on the top of both the left and right hand pages in order it goeth to 9 tenths, which three Decimal Numbers under them anſwering to every degree, and tenth part of a degree, from 1 degree to 29 in the firſt two pages, the next two pages are in the ſame order, and hath alſo 12 Columns; the firſt to the left hand and the ſeventh (being the firſt) Column on the right hand page beginneth with 30, and goeth downward in order to 59, which ſignifie degrees, and the other 10 Columns have the Decimal Number anſwering to the Degrees, and each tenth part of a degree, as the two firſt Pages do; As admit I would know what Decimal Number doth belong to 10 degrees and 5 tenths; I look in the firſt 2 pages, and in the 7th Column I find 10 degrees. Then look at the Head of the Table

for five Tenths, and under the Figure 5 and againſt ten in the little Column I find 00: 1852 the Decimal Tabular Number deſired; and ſo you may find any other Number belonging to any Degree, and any tenth part of a Degree, to 89 Degrees and 9 tenth parts of a Degree.

The Uſe of this Table.

This Table is purpoſely fitted for the uſe of Canoniers, it being a very ready and eaſie way of finding inacceſſible Diſtance or Altitude, without the trouble of the Books of Trigonometry, which a man cannot conveniently carry to all places along with him, nor well uſe them without ſome Table to lay them on before him, of which thing a man abroad will very ſeldome be provided with, perhaps ſome may ſay, that they had rather work it by Trigonometry, or they can do it neer as ſoon. But they can do it no truer, except that they have their Angle taken neerer then the tenth part of a Degree, which muſt be obſerved with ſome very large and curious Inſtrument, and very probable it will be of great Price alſo, which very many cannot purchaſe, it muſt be no ſmall Inſtrument that a man can take an Angle with to the tenth part of a degree, for if you fail in curiouſly taking the Angle with your Inſtrument you may well miſs of the truth of your diſtance or Altitude

tude; for if you make an error there, neither this Table nor the Table of Logarithms, Sines and Tangents, can help you to any true Diſtance or Altitude; yet I may ſay further, that all Cannoniers do not know the uſe of Logarithms, Sines and Tangents, nor how to find a diſtance Geometrically, or by Trygonometry; but if they have a ſmall portion of Arithmetick; this Table will do them a kindneſs, and I ſhall think my time well ſpent in doing good to any of my Brethren, therefore I will endeavor to explain the uſe of it as aptly as I can, that the meaneſt capacity may underſtand it, and how with the help of a Quadrant, or ſome other convenient Inſtrument to obſerve the Angle, to finde any Diſtance or Altitude within two or three Miles; If you can ſee the Object firſt from the place, where you intend to plant your Gun; obſerve on which ſide of your Gun you can have a convenient meaſured diſtance, at a right Angle, or 90 degrees from a ſtraight line to the Object that you deſire the diſtance of; then meaſure that diſtance 60, 70, 80, 90, 100 paces or yards, which you pleaſe, the more the better, and the truer will your diſtance be found; then ſtanding at the end of your meaſured diſtance, turn your Quadrant or other Inſtrument, ſo that the ſtreight eye of the Quadrant point exactly to the place where

you began to meaſure, and the Limb or Arch of the Quadrant face towards the object, Then ſcrew your Quadrant faſt, then move the Index till through the Sights you ſee your Object; Then ſee what Degree the Point of the Index or Thread cutteth, and how many tenth parts it is above the Number of whole Degrees. Having thus carefully obſerved your Angles, and Meaſured the diſtance of your two Stations, you will be fitted for the uſe of part of this Table.

EXAMPLE I.

By the Figure hereunto annexed, ſuppoſe your Gun were to be planted at A, to play at ſome Fort or Caſtle at C and D; Firſt, meaſure out a diſtance from the point or place at A to B, which ſuppoſe 100 paces or yards; then carry your inſtrument to B, and take the quantity of that Angle, which ſuppoſe to be as near as the Inſtrument will take it, 81 degrees and 3 tenth parts of a degree; then look that Number in the Table beforegoing, finding 81 at the ſide towards the left hand, and under the Figure 3 at the top, I find 65350, which multiplied by 100 is 6535 00. Here Note, That in all the parts of this Table you muſt cut off 4 Figures towards the right hand, and then there will remain 653 paces, and the Figures cut off are a Decimal Fraction

ction of 10000 which is here in the Example the half of 10000, which ſignifieth half a pace; ſo I conclude my diſtance from A to C, to be 653 paces, it makes no matter for the half pace. You are alſo to underſtand that 1056 paces, accounting five Foot to the pace, maketh an *Engliſh* mile, ſo the diſtance of A. C. is half a mile, and almoſt half a quarter, or half a mile and almoſt a furlong, your work will be ſomething truer, if your Meaſured diſtance were longer, and the Angle at B leſs, then ſuppoſe C. D. to be the heigth of ſome Tower, and you were to find the Altitude thereof; then with your Quadrant ſtanding ot A. obſerve the Altitude, which ſuppoſe to be 3 degrees and ſix tenth parts of a degree, for which I look in the firſt part of the Table, and againſt three in the little Column, and under 6 at the head I find 629, which you muſt multiply by the before-found length A C 653, and the product 410737. Then cut off the four laſt Figures, as before directed, and you will have 41 for the Altitude of the Tower, or the line C D. And if you would know the quantity of the three Figures cut off, multiply them by 5, by reaſon five Foot maketh a Geometrical pace, and the product will be 3685, which will not be one Foot, by reaſon you are always to cut off four Figures

therefore ſeeing that 12 inches make one foot, multiply 3685 by 12, and the product will be 44220, which is 4 inches and 4220 parts of 10000 of an inch. But in my opinion this is more curious then neceſſary, yet I think good you ſhould know what that Fraction ſignifies, and how to reduce it into a more common Number. So I hope by this you may be able to finde any convenient Diſtance or Altitude, the ſame may be performed, if you ſtand on the top of any high Tower, Steeple or Cliff, whoſe height is known, or found out by the former given Rules.

EXAMPLE II.

Suppoſe in the former Figure I were ſtanding on ſome Tower, or top of ſome Cliff or Steeple, whoſe height from the level of the Ground were 41 paces, as the line D. C. And I would know how far it is to A. Then with my Quadrant I obſerve the Angle at D, and finde it to be 86 Degrees and 4 tenths of a Degree, for which Number I look in the latter part of the Table, and againſt 86 in the little Column, and under 4 at head, I find 158946, which muſt be multiplied by 41, the product is

6516786

6516786, which is above one pace leſs then the Diſtance before found, yet near enough to the truth, for ſo ſhort a Meaſur'd Diſtance as 41 paces. For the errour will be as much in Trigonometry, unleſs we could know the Angle nearer then the 1 tenth of a Degree, which is as near as any common inſtrument will give by Obſervation. So by this Rule you may obſerve all the convenient Diſtances of any Ground round about any Caſtle or Fort, which may be of good uſe, if Enemies come near, provided that the Ground lie level with the Baſe.

But this will not do, unleſs there be a right Angle at one end of the meaſured diſtance, which ſometimes cannot be with convenience had, and therefore I have added a ſmall cannon of Sines and Tangents to every 10th. part of a degree, which is as near as any common Inſtrument will take an Angle.

The Deſcription of the Artificial Sines and Tangents are as followeth.

I Have ſet them down in a contrary forme to all others, as I have ſeen the firſt little column is degrees from 0: to 1:2:3 &ſo to 29de-

grees in the firſt *Page*, and on the Right hand of this little Column followeth ten more Columns on both the *Pages* as they lie open to your view, and theſe ten Columns are noted at the Head with 0. 1. 2. 3. 4. 5. 6. 7. 8. 9. Which ſignifie every tenth part of a degree, and as theſe two firſt *pages* are noted at the Head, ſo are the *pages* following, and the little Column continued from 29 degrees to 89, and there the little Column endeth as to the Sines.

Then next after the Sines followeth the Tangents, in the ſame form and order as the Sines with Tangents written at the Head of the Tables, the Deſcription being juſt the ſame of the Sines, I need ſay no more of them.

I have alſo added a ſmall Cannon of Logarithms, ſo far as may be convenient for the taking of diſtances in Geometry call'd paces, which is 5 Foot to the pace, and in that Meaſure this Logarithm will ſerve for a diſtance of two mile almoſt.

The Deſcription of the Logarithms.

Theſe Logarithms are ſet ſomthing contrary to others, and do contain as many Columns as the Sines and Tangents do, the firſt Column

to

to the left hand is noted at head with num. beginning in the firſt left hand *page* with 0, and increaſing downward to 290 at the bottom of the ſame *page*, and ſo goeth on in the firſt Column of each left hand *page* to 2090, and it increaſeth by tens, and the ſupplying Numbers are ſet at head in the ten Columns towards the right hand, and noted with 0. 1: 2. 3. 4. 5. 6. 7. 8. 9. ſo having found the firſt Figures in the little Column towards the left hand, you are to find the laſt Figure of the Number at the head of the Table, and then at the Angle of Meeting, as in the former Tables you may find the Logarithm to any Number deſired, if it be not more then 2099, as will better appear in the Uſe following.

The Uſe of the Sines and Logarithms in the firſt Example in *page* 159. For the uſing of the Sight-Rule, firſt you muſt underſtand that the firſt Figure towards the left hand of any Logarithm is called Caracteraſtick, and they are to be altered when there is any Fraction belonging to a whole Number, if there be but one Figure a Fraction, then you muſt make the firſt figure one place leſs, as here the Number given is 8:7, then look in the firſt *page* of the Logarithms in the little Column for 80. and in the ninth Line of that Column

Column you may finde it, then guiding your eye along that line till you come under 7 at the head of the right hand page, and in the Angle of Meeting you may finde 1:93952 then by reaſon the laſt Figure of the Given Number is a Fraction, you muſt account the firſt Figure of your Logarithm to be a Cipher, then it will ſtand thus, 0 93952, and this Logarithm is the proper Logarithm for 8 foot, and 7 tenths of a foot; then look in the Table of *Sines* for the Sine of 2 degrees and 6 tenth parts, which you may alſo finde it in the firſt and ſecond page thereof; and the third line in the firſt little Column you finde 2, then guide your eye in the ſame line to the right hand page, and under 6 at the head in the Angle of Meeting you may find 8:65670, which is the Artificial Sine deſired for two degrees, & 6 tenth parts of a degree, then having found both the Logarithm and the Sine, add them together, and the Sum will ſtand thus, 9:59622, and this is a defective Logarithm, it being the Logarithm of leſs then one, therefore it can be but the Logarithm of a Fraction, therefore put by the firſt Figure thereof, and imagine it to be a Cipher, and then look for 0:59622, and in the firſt page and firſt line under 4, at the head I find 0:60206, which is a little too much, and by

by this you may underſtand that it is almoſt four tenths of a foot.

But this is not near enough the truth, therefore you may take the firſt Figure of the Logarithm to be a 1, and then it will ſtand thus 1:59622, and the neareſt to this I finde in the ſecond page, and the fourth line of the Logarithmes, and under 9 at Head, and the Numbers anſwering to it in the firſt little Column is 3, and at the head 9, which will be 3 Decimal inches, and 9 tenth parts of a Decimal inch; but you may come nearer to the truth then this, if you will, but ſo Pole the firſt Figure of your Logarithm by a 2, then the Logarithm will ſtand thus 2:59622, and the neareſt to this I finde in the fourth page againſt 390 in the firſt Column, and under 5 at the Head, and this is as near as this Logarithm will do it without making proportion, and it will be a little too much, and will ſtand thus, 3 Decimal inches, and 95 parts of 100 of a Decimal inch, or tenth of a foot.

You may finde another way of working of this in *page* 160 before-going, where the length of the Gun is put in Decimal inches or tenths of a Foot, which will be 87, the Logarithm thereof is 1:93952, and the Sine of two degrees and 6 tenths is 8:65670, which being added together makes 059622; then ſuppoſe the

the firſt Figure thereof to be a 2, which is here a Cipher, and it will be thus 2:59622, for which Number I look among the Logarithmes, and the neareſt to it I finde to be 2:59660, which is a little too much, and againſt it to the left hand in the little Column is 390, and over it at head is 5, which 5 you muſt place in the room of the Cipher, and your Number will be thus 3:95. you are to remember that if in ſtead of a Cipher for the firſt place of the Logarithm you place a 1, then the laſt Figure of the Number ſought is a Fraction; and if in the ſame place you put a 2, the two laſt Numbers of the Sum ſought for are two Fractions, as in this caſe 3 Decimal inches and 95 parts of a 100 of a Decimal inch.

How you may make theſe Logarithmes ſerve to 20000 and upwards, by one Multiplication, and the difference of two Logarithmes.

Theſe Logarithmes as they are direct to 2099, admit I would have them to ſerve to 20988; firſt take the difference betwixt the Logarithm of 2099, and the Logarithm of 2098, which you will find to be 20, then multiply 20 by 8, and the product is 160, cut off the laſt place to the right hand, and there

here will remain 16, which muſt be added to the Logarithm of 2098, which is 3:32181, and 16 added, the Logarithm will be 3:32197; but here is ſomthing more to be known in this caſe, before I paſs it; you muſt underſtand, that the Characteriſtick, or the firſt Figure or Cipher of the Logarithm tells you how many Figures is belonging to that Logarithm, for if the firſt place to the left hand be a Cipher, then the Number thereunto belonging is but of one place; but the firſt Figure being a 1, then the Number belonging to it is of two places; but if the Number be of 3 places, then the firſt Figure of the Logarithms is but a 2: and if the Number be of 4 places, as here in this Logarithm 2098, you find the firſt figure of the Logarithm to be 3, but here by making of the Logarithm to ſerve to five places, which is 20988, I muſt make the firſt Figure of the Logarithm to be a 4, then the perfect Logarithm of 20988 will be 4:32197, and ſo with little or no labour you may make this ſhort bit of Logarithmes ſerve to more then 20 thouſand, and what hath been ſaid by this Figure of 8, the ſame may be done by any other Figure, always remembring to cut off the laſt place of the difference multiplied, and to adde one to the firſt figure of the Logarithm to make it 4.

Ha-

Having a Logarithm given to find a Numbe by proportion, one or two places more the the Characteraſtick or the firſt Figure of th Logarithm.

Let the Logarithm given be 2:59622, th next leſſer Logarithm is 2:59550, which i the Logarithm of 394, then ſubſtract the Logarithm of 394 from the Logarithm of 395, and their difference will be 110, then ſubſtract the Logarithm of 394 from the Logarithm given, 2:59622, and their difference is 72, then ſuppoſe the difference betwixt 294 and 295 to be ten or a 100, and you may take another Figure or two to Joyn to 394, thus if you divide 72 with one Cypher, it will ſtand thus, 720, and it divided by 110 the Quotient is 6 which you may place to the right hand of 394, and it will be 3946, but if you put two Cyphers to 72 and divide it by 110, and the Quotient will be 65, which being placed to the right hand of 394, will be thus 39465, ſo by Diviſion you increaſe your Number as you pleaſe to 30 or 40 thouſand, which will be as far as you will have any occaſion for.

Multiply

Multiplication by Logarithms.

Look for the Logarithms of the two Numbers that are to be Multipli'd, and add them together, and the ſum is the Logarithm of the Product thus, if you were to Multiply 23 by 75, the Logarithm of 23 is 1:36173, and the Logarithm of 75 is 1:87506, which added together, is 3:23679, which is the Logarithm of 1725, and ſo much is the Product of 75 Multiplied by 23, and the like may be done with any other Numbers within the Compaſs of this Logarithm.

Diviſion by the Logarithms.

This is done by ſubſtraction, if you would divide 1725 by 75, look the Logarithms of each, and ſet the bigeſt Logarithm uppermoſt, and ſubſtract the leſſer from it, and the Remainder is the Logarithm of the Quotient, the Logarithm of 1725 is 3:23679, and the Logarithm of 75 is 1:87506, which being ſubſtracted, the Remainder is 1:36173, which is the Logarithm of 23 the Quotient deſired.

How

How to take the Arithmetical Complement of any Sine or Logarithm.

The Arithmetical Complement of any Sine, Tangent or Logarithm, is no other but to ſubſtract it from 1:000000, which is one place more then the Sines or Logarithms, and what remains is the Arithmetical Complement, but this may be as truly done as you take them out of the Book, thus, beginning at the left hand, ſubſtract each Figure from 9, and ſet down the remainder for your uſe, and the laſt Figure towards the right hand you are to ſubſtract from 10, and ſet down the remainder, as ſuppoſe it were the laſt Logarithm of 23, which is 1:36173, then beginning at one to the left hand I take one from 9 and there remains 8, then take 3 from 9 remains 6, and 6 from 9 remains 3, and 1 from 9 leaves 8, then 7 from 9 reſts two, and the laſt Figure, 3 from 10 leaveth 7, which ſet down in order will ſtand thus, 8:63827, and as you do by the Logarithms, the ſame way will ſerve for the Sines, and as for the Tangents they are the Arithmetical Complements one of another in their Complements to 90 degrees, for if you have the Tangent of 30 degrees, the Complement to 90 is 60, and that

Tangent

D
C
A
B
Place this at the beginning of the lines to lye open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Tangent of 60 is the Arithmetical Complement of that Tangent of 30 Degrees, or you may take them as the other, taking care after you come to the Tangent of 45 degrees, for there you muſt caſt away the firſt Figure to the left hand, and take the remainders to 9, and the laſt to 10 as before directed.

How to work the Golden Rule, or Rule of Proportion, by the Logarithmes.

I having ſhewed you before how to take the Arithmetical Complement, the Golden Rule may be performed by one Addition. Having the Diameter of one Circle and its Circumference, and the Diameter of another Circle given to find the Circumference of the ſecond Circle.

Let the Diameter of the firſt Circle be 113, and the Circumference 355, and the Diameter of the ſecond Circle 30; firſt, look the Logarithm of 113, and take the Arithmetical Complement of that Logarithm 113, being the firſt of the three Proportional Numbers given, and in all Caſes if you work the Rule of Three by the Logarithmes, you muſt either add the Logarithm of the ſecond and third together, and from that Sum ſub-

ſtract the Logarithm of the firſt, and the remainder is the Logarithm of the fourth proportional Number or ſum deſired, but if you take Arithmetical Complement of the firſt and add them all three together, it will be the ſame as if you add and ſubſtract thus the

Logarithm of	113.	2:05308
The Logarithm of	355,	2:55023
the Logarithm of	30,	1:47712
add the two laſt, makes		4:02735
the firſt ſubſtract,		205308
the remainder is the Logar. of 94:2:		1:97427

Which is 94 and 2 tenths.

And by Addition, thus

the Arithmetical Complement of the Logarithm of	113, is	794692
the Logarithm of	355, is	255023
the Logarithm of	30, is	1:47712
the Logarithm is the ſame with the former,		1:97427

and eaſier done in my Opinion, but this you muſt always remember, to caſt away the Radius or firſt Figure to the left hand, or otherways you will have ſeven places in ſtead of ſix, and by this way you may work any thing in the Rule of three by one Addition.

How

How to Extract the ſquare Root by the Logarithms.

This is very eaſily done, having any ſquare Number given to find the Root thereof, you muſt look the Logarithm of the Number given, and ſet it down, and take the half of it, or divide it by 2. which is all one, and the remainder or Quotient is the Logarithm of the ſquare Root deſired, I would know what is the ſquare Root of 2025, I look the Logarithm thereof, and it is 3:30642, and the half of it is 1:65321, which I find at the beginning of the Logarithm, to be the Logarithm of 45, and that is the ſquare Root of 2025, for if you Multiply 45 by 45, the product will be 2025, which will prove the Root to be true Extracted.

How to Extract the Cube Root by the Logarithms.

Having any Number given that hath a Cube Root, find the Logarithm thereof, and take one third part of that Logarithm, which is by dividing it by 3, and the Quotient is the Logarithm of that Cube Root deſired; but if it be a Number that

hath not a Cube Root in a whole Number, then the Root will be found to be a whole Number, and part of a whole Number, which may be noted in a Decimal Fraction, as by the second Work following.

EXAMPLE.

If it be desired to have the Cube Root of 1728, the Logarithm therof is 3 23754, which being divided by 3, the Quotient will be 107918, which found among the Logarithms will answer to the Number 12, which is the Root desired, and may be thus proved; multiply 12 by 12, the product is 144, which if you multiply by 12, that product will be 1728, which is the Cube of 12, the Number first given.

To finde the Cube Root of a Number, which will have a Decimal Fraction.

Suppose the Number given be 2098, the Logarithm is 3:32181, which divided by 3 the Quotient will be 1:10727. which Number I seek, accounting the first Figure to be a 3, and the neareſt I finde to it is 3:10721, which answers to 12.80, which is somthing too little; but if I should take 3:10755, which

which anſwereth to 12:81, it would be a great deal too much, for the firſt is but 6 too little, and the ſecond is 28 too much, and thoſe that pleaſe may make proportion, as is before directed.

How to find any inacceſſeable diſtance within common ſight, by help of an Inſtrument, &c.

Firſt, finde a convenient place where you may obſerve the Object, or Objects, at two ſeveral Stations; then ſet up an Inſtrument at the firſt ſtation, and take the quantity of the Angle between the Object and the ſecond Station, and Note that down in your book; then meaſure the diſtance from the firſt ſtation to the ſecond, and there ſet up the Inſtrument again, and carefully find the Angle between the firſt ſtation and the Object, and note that alſo in your book, then add both thoſe Angles together, and ſubſtract their Sum from 180, and the remainder is the Angle at the Object, (for in any Triangle whatſoever, all the three Angles added together make 180 degrees,) having found the Angle at the Object, the meaſured diſtance will be a ſide oppoſite to it, then the proportion will be thus; as the Sine of the Angle at the Object is to the Logarithm of the meaſured

ſured diſtance, ſo is the Sine of the Angle taken at the firſt ſtation to the Logarithm of its oppoſite ſide, which is the diſtance between the object and the ſecond ſtation.

By the ſame Rule you may find the diſtance of the object, and the firſt ſtation, for the Sine of the Angle at the object, and the Logarithm at the meaſured diſtance are the ſame, but inſtead of the Angle at the firſt ſtation, you muſt take the Angle at the ſecond ſtation.

EXAMPLE

In the latter end of Summer, 1675 Mr. *Richard Pyne*, Maſter Gunner at the *Block-houſe* at *Graves-End*, deſired ſeveral Gunners dwelling about *London*, to come down to ſhoot ſome Ranges out of the *Block-houſe* down the River, he having leave (as he ſaid) from the Right Honourable, the Maſter-General of his Majeſties Ordnance; whereupon in *October* then next following, my ſelf and ſeveral others went down for that purpoſe; Ranges being the principal thing wanting in this Art.

And when we came down, after ſome diſcourſe with my worthy Friend Mr. *Pyne*, he went to acquaint his Governour to what end

we

were come, but (as he told us) afterwards the Governour refuſed to give us leave, which very much troubled us that we ſhould loſe our time and ſpend our money to no purpoſe; however to paſs away the time while we ſtaid there; having an Inſtrument and Chain, we imploy'd our ſelves to find the diſtance between the two *Jack-ſtaves* there, which was done upon the upper end of the ground on the back ſide of the *Block-houſe*, a ſmall Figure of the manner of which Work followeth at the end of this Example.

The Line A. B. is the meaſured diſtance; the firſt ſtation of A. and the Angle between *Graves*-End *Jack* at C. and the ſecond ſtation at B. is 63 degrees and 10 minutes, and the Angle at D. A. B. is 84 deg. and 50 min: and ſo much is the quantity of the Angle between the *Jack-ſtaff* at *Tilbury* and the ſecond ſtation; then having obſerved the Angles of both the objects, meaſure from the firſt ſtation to the ſecond, and ſet down the meaſured diſtance 220 Yards.

Then you muſt ſet up the Inſtrument at the ſecond ſtation at B, and take the quantity of the Angle from the firſt ſtation to C, the place of the Flag on *Graves*-End ſide, which is 33 degrees and 40 minutes.

Then from the firſt ſtation at A to D, you will find to be 82 Degrees and 40 Minutes, which is the quantity of the Angle of A.B.D.

Then to find the Angle at C, take the Angle obſerved at the firſt and ſecond Station, and add them together, the firſt being 63:10, and the ſecond is 33:40, which added together makes 96:50, which being ſubſtracted from 180 Degrees, remains for the Angle at C 83 Degrees and 10 minutes. And then of the Triangle A,B,C, you have gained all the Angles and one ſide, which is the meaſured diſtance A B, 220 yards; the other ſides may be found thus, as the Sine of 83 degrees and 10 minutes, (which is the Angle found at *Graves-end Jack-Staff*, is to the meaſured diſtance 220, ſo is the Angle at A 63 degrees and 10 minutes to the ſide C, B, 197 yards, and 7 tenths of a yard.

And again, as the Sine 83:10 is to the ſide 220, ſo is the Sine of 33.40, to the ſide A C, 123 yards, and by this means you have gained all the three ſides, *viz.* A C, 123, B C, 197:7, and A B, 220. Now it will be required to find the length of a Perpendicular, that will fall from the Angle C on the Line A B, which may be done thus, as the Radius or Sine of 90, is to the ſide A C, 123,

ſo

ſo is the Sine of the Angle at A, 63 Degrees and 10 to the length of the Perpendicular deſired 109.8.

You may find the Angle at the Jack-ſtaffe on *Tilbury* ſide, this the Angle at the firſt ſtation is 84 degrees and 50 minutes, which is litte more then eight tenths of a degree, and the Angle at the ſecond ſtation to *Tilbury*, is 82 degrees and 8 tenths, which being added both together, makes 167: 6 tenths, which being ſubſtracted from 180, remains 12 degrees and4 tenths,which is the Angle at *Tilbury-Jack-ſtaff*, then as the Sine of 12 degrees & 4 tenths,Arithm.Com. is 066801
to the oppoſite ſide AB.220Yards 234242
ſo is the Sine of 84 degr. 8 tenths 999821
to the ſide B. D.----1020 Yards, 300864

and for the finding of the other ſide, the two firſt Numbers of the former work ſerveth again, ſo you have no more to do then to add to them the Sine of 82 degrees and 8 tenths,which is 999656, and their ſum will be 300699, which is the Logarithm of 1016, which is the ſide A D. or the diſtance from the firſt ſtation to the *Jack-ſtaff* at *Tilbury*, from which ſubſtract the length of the Perpendicular before found 109:8, the remainder will be 906 Yards and 2 tenths of a Yard, from which take 880, the Number of

Yards

yards in half a mile, and there will remain 26 yards, and ſo betwixt the two Jack-ſtaves is found to be half a mile and 26 yards, as for the Fraction it is needleſs.

If any will be ſo curious, they may find the length of the Perpendicular that will fall upon the Line of Meaſured Diſtance A B; and ſubſtract the leſſer Perpendicular from the greater, and the remainder is the diſtance in yards.

I hope I have been ſo plain in this, that any that will give their mind to this kind of Learning, may be able to take any inacceſſible diſtance within common ſight.

Having two Sides and an Angle included to find the oppoſite ſide.

As in the Diagram hereunto annexed, let the ſide B C 197:7 be given, and the ſide BD 10,19 then ſubſtract the Angle A B C, which is 33 d 40 from the Angle A B D 82 d 40, and their diff r nce is 49 d, and ſo much is the quantity of the Angle C B D, then ſay as the ſum of the ſides, which is 1216:7 is to the difference of the ſides 821:3, ſo is the Tangent of half the Angles unknown, which you muſt find thus, ſubſtract 49 d from 180 d & the difference is 131 d, the half of which is 65 d and 30 minutes, or five tenth parts of a degree, the half of the Angles unknown, the fourth Number

ber will be the Tangent of the difference of the two Angles unknown, which being added to half the Angles unknown maketh the greater Angle, and if it be ſubſtracted from half the Angles unknown, there will remain the leſſer Angle.

	Compl. Arithm:
of the Logr. of the ſum of the ſides.	1216:7:6:91582
The Log. of the difference:	821:3: 291450
Tang. of half the Angles unknown	65:5 : 034130
The Tangent of the difference is	56:10: 17162

then add 56 to 65:5 and the ſum is 121 d 5, which is the Angle B C D, then ſubſtract 56 from 65:5, and the remainder is the Angle B D C, 9 d 5, now you have all the Angles and two ſides, now the diſtance of C D may be found without the Perpendicular, thus as the Sine at D 9 d 5 is to the ſide C B 197:7, ſo is the Sine at B 49 to the ſide C D 904. Which differeth from the former but a little.

Having three ſides of a Triangle given to find on what Part of the Baſe the Perpendicular muſt fall.

There being a little ſpare paper, *I* will here ſhew you how to find upon what place of the Baſe the Perpendicular will fall, take the Baſe to be the meaſured Diſtance, which is as before 220 yards, and the ſide A C 123 yards, and the third ſide *B* C 197 yards and 8 tenths of a yard, then having the three ſides given the proportion will be thus; as the baſe A *B* 220 is to the ſum of both the other ſides, 320 and 8 tenths, *viz.* A C and *B* C, ſo is the difference of the ſame two ſides 74 and 8 tenths to 63 and 6 tenths, which being added to the *Baſe* A *B*, 220 makes 283:6 tenths, the half whereof is 141:8 tenths, the Diſtance of the Perpendicular from *B*, then ſubſtract 63 and 6 tenths from 220, and the remainder is 156 and 4 tenths, the half is 78 and 2 tenths, the Diſtance from A to the Perpendicular, and ſo you may finde the diſtance of any Perpendicular from each end of the baſe at your pleaſure.

A Table of Sines, Tangents and Logarithms follow.

Sines

	0	1	2	3	4
0	0.00000	7.24188	7.54291	7.71900	7.84393
1	8.24185	8.28324	8.32103	8.35578	8.38796
2	8.54281	8.56400	8.58419	8.60349	8.62197
3	8.71880	8.73303	8.74680	8.76015	8.77310
4	8.84539	8.85729	8.86874	8.87994	8.89090
5	8.94030	8.94887	8.95728	8.96553	8.97363
6	9.01923	9.02639	9.03342	9.04034	9.04715
7	9.08589	9.09202	9.09807	9.10402	9.10990
8	9.14355	9.14891	9.15421	9.15943	9.16460
9	9.19433	9.19909	9.20380	9.20845	9.21305
10	9.23967	9.24395	9.24818	9.25237	9.25652
11	9.28060	9.28448	9.28833	9.29214	9.29591
12	9.31788	9.32143	9.32495	9.32844	9.33190
13	9.35209	9.35536	9.35860	9.36182	9.36502
14	9.38367	9.38670	9.38171	9.39269	9.39566
15	9.41300	9.41581	9.41861	9.42139	9.42416
16	9.44034	9.44297	9.44559	9.44819	9.45077
17	9.46593	9.46841	9.47086	9.47330	9.47573
18	9.48998	9.49231	9.49462	9.49692	9.49920
19	9.51264	9.51484	9.51702	9.51919	9.52135
20	9.53105	9.53613	9.53819	9.54025	9.54229
21	9.55433	9.55630	9.55826	9.56021	9.56215
22	9.57357	9.57545	9.57731	9.57916	9.58100
23	9.59188	9.59366	9.59543	9.59720	9.59895
24	9.60931	9.61101	9.61270	9.61438	9.61606
25	9.62595	9.62757	9.62918	9.63079	9.63239
26	9.64184	9.64339	9.64494	9.64647	9.64800
27	9.65705	9.67853	9.66001	9.66148	9.66295
28	9.67161	9.67303	9.67445	9.67586	9.67726
29	9.68557	9.68694	9.68829	9.68965	9.69100

5	6	7	8	9
7.94084	8.02002	8.08696	8.14495	8.19610
8.41792	8.44594	8.47226	8.49708	8.52055
8.63968	8.65670	8.67308	8.68886	8.70409
8.78567	8.79789	8.80978	8.82134	8.83261
8.89464	8.90417	8.91349	8.92261	8.93154
8.98157	8.98937	8.99704	9.00456	9.01196
9.05386	9.06046	9.06696	9.07337	9.07968
9.11570	9.12142	9.12706	9.13263	9.13813
9.16970	9.17474	9.17973	9.18465	9.18952
9.21761	9.22211	9.22657	9.23098	9.23535
9.26063	9.26470	9.26873	9.27273	9.27668
9.29965	9.30336	9.30704	9.31068	9.31430
9.33534	9.33874	9.34212	9.34547	9.34879
9.36818	9.37133	9.37445	9.37755	9.38062
9.39860	9.40152	9.40442	9.40730	9.41016
9.42690	9.42962	9.43233	9.43502	9.43769
9.45334	9.45589	9.45843	9.46095	9.46345
9.47814	9.48054	9.48292	9.48529	9.48764
9.50148	9.50373	9.50598	9.50821	9.51043
9.52349	9.52563	9.52775	9.52986	9.53196
9.54432	9.54634	9.54836	9.55036	9.55235
9.56407	9.56599	9.56790	9.56980	9.57169
9.58284	9.58460	9.58648	9.58829	9.59009
9.60070	9.60244	9.60417	9.60589	9.60761
9.61773	9.61939	9.62104	9.62268	9.62432
9.63398	9.63557	9.63715	9.63872	9.64028
9.64953	9.65104	9.65255	9.65406	9.65556
9.66441	9.66586	9.66730	9.66875	9.67018
9.67866	9.68006	9.68144	9.68282	9.68420
9.69234	9.69368	9.69501	9.69633	9.69765

	0	1	2	3	4
30	9.69897	9.70028	9.70158	9.70283	9.70418
31	9.71184	9.71310	9.71435	9.71560	9.71685
32	9:72421	9.72542	9.72663	9.72783	9.72902
33	9.73611	9.73727	9.73843	9.73959	9.74074
34	9.74756	9.74868	9.74980	9.75091	9.75202
35	9.75859	9.75967	9.76075	9.76182	9.76289
36	9.76922	9.77026	9.77130	9.77233	9.77336
37	9.77946	9.78047	9.78147	9.78246	9.78346
38	9.78934	9.79031	9.79127	9.79224	9.79319
39	9.79887	9.79981	9.80074	9.80166	9.80259
40	9.80307	9.80897	9.80987	9.81076	9.81165
41	9.81694	9.81781	9.81868	9.81954	9.82040
42	9.82551	9.82635	9.82719	9.82802	9.82885
43	9.83378	9.83459	9.83540	9.83621	9.83701
44	9.84177	9.84255	9.84334	9.84411	9.84489
45	9.84948	9.85024	9.85100	9.85175	9.85250
46	9.85693	9.85766	9.85839	9.85912	9.85984
47	9.86413	9.86483	9.86554	9.86624	9.86693
48	9.87107	9.87175	9.87243	9.87311	9.87378
49	9.87778	9.87844	9.87909	9.87975	9.88040
50	9:88425	9:88489	9:88552	9:88615	9:88678
51	9:89050	9:89111	9:89173	9:89233	9:89294
52	9:89653	9:89712	9:89771	9:89830	9:89888
53	9:90235	9:90292	9:90349	9:90405	9:90462
54	9:90796	9:90851	9:90905	9:90960	9:91014
55	9:91336	9:91389	9:91442	9:91495	9:91547
56	9:91857	9:91908	9:91959	9:92010	9:92060
57	9:92359	9:92408	9:92457	9:92506	9:92554
58	9:92847	9:92889	9:92936	9:92983	9:93030
59	9:93307	9:93352	9:93397	9:93442	9:93487

5	6	7	8	9
9:70547	9:70675	9:70803	9:70931	9:71057
9:71808	9:71932	9:72055	9:72177	9:72299
9:73022	9:73140	9:73259	9:73376	9:73497
9:74189	9:74303	9:74417	9:74531	9:74644
9:75313	9:75423	9:75533	9:75642	9:75751
9:76395	9:76501	9:76607	9:76712	9:76817
9:77439	9:77541	9:77643	9:77744	9:77845
9:78445	9:78543	9:78642	9:78739	9:78837
9:79415	9:79510	9:79605	9:79699	9:79793
9:80351	9:80443	9:80534	9:80625	9:80716
9:81254	9:81343	9:81431	9:81519	9:81607
9:82126	9:82212	9:82297	9:82382	9:82467
9:82968	9:83051	9:83133	9:83215	9:83297
9:83781	9:83861	9:83940	9:84020	9:84098
9:84566	9:84643	9:84720	9:84796	9:84873
9:85324	9:85399	9:85473	9:85546	9:85620
9:86056	9:86128	9:86200	9:86271	9:86342
9:86763	9:86832	9:86901	9:86970	9:87039
9:87446	9:87513	9:87579	9:87645	9:87712
9:88105	9:88169	9:88234	9:88298	9:88362
9:88741	9:88803	9:88865	9:88927	9:88989
9:89354	9:89415	9:89475	9:89534	9:89594
9:89947	9:90005	9:90063	9:90120	9:90178
9:90518	9:90574	9:90630	9:90685	9:90741
9:91069	9:91123	9:91176	9:91230	9:91283
9:91599	9:91651	9:91703	9:91753	9:91806
9:92111	9:92161	9:92211	9:92260	9:92310
9:92603	9:92651	9:92699	9:92747	9:92795
9:93077	9:93123	9:93169	9:93215	9:93261
9:93532	9:93577	9:93621	9:93665	9:93709

	0	1	2	3	4
60	9·93753	9·93797	9·93840	9·93884	9·93927
61	9·94182	9·94224	9·94266	9·94307	9·94349
62	9·94593	9·94633	9·94674	9·94714	9·94753
63	9·94988	9·95027	9·95065	9·95103	9·95141
64	9·95366	9·95403	9·95440	9·95476	9·95513
65	9·95728	9·95763	9·95800	9·95833	9·95868
66	9·96073	9·96107	9·96140	9·96173	9·96207
67	9·96403	9·96435	9·96467	9·96498	9·96530
68	9·96717	9·96747	9·96777	9·96808	9·96838
69	9·97015	9·97044	9·97073	9·97102	9·97130
70	9·97299	9·97326	9·97353	9·97381	9·97408
71	9·97567	9·97593	9·97618	9·97645	9·97670
72	9·97821	9·97845	9·97870	9·97894	9·97918
73	9·98060	9·98083	9·98105	9·98128	9·98151
74	9·98284	9·98306	9·98327	9·98349	9·98370
75	9·98494	9·98515	9·98535	9·98555	9·98574
76	9·98690	9·98709	9·98728	9·98746	9·98765
77	9·98872	9·98890	9·98907	9·98924	9·98941
78	9·99040	9·99056	9·99072	9·99088	9·99104
79	9·99195	9·99210	9·99224	9·99238	9·99252
80	9·99335	9·99348	9·99362	9·99375	9·99387
81	9·99462	9·99474	9·99486	9·99497	9·99509
82	9·99575	9·99586	9·99596	9·99607	9·99617
83	9·99675	9·99684	9·99693	9·99702	9·99711
84	9·99761	9·99769	9·99777	9·99785	9·99792
85	9·99834	9·99841	9·99847	9·99854	9·99860
86	9·99894	9·99899	9·99904	9·99909	9·99914
87	9·99940	9·99944	9·99948	9·99952	9·99955
88	9·99973	9·99976	9·99979	9·99981	9·99983
89	9·99993	9·99995	9·99996	9·99997	9·99998

5	6	7	8	9
9.93970	9.94012	9.94055	9.94097	9.94140
9.94390	9.94431	9.94472	9.94512	9.94553
9.94793	9.94832	9.94871	9.94910	9.94949
9.95179	9.95217	9.95254	9.95292	9.95329
9.95549	9.95585	9.95621	9.95657	9.95692
9.95902	9.95937	9.95971	9.96005	9.96039
9.96240	9.96273	9.96305	9.96338	9.96370
9.96561	9.96593	9.96624	9.96655	9.96686
9.96868	9.96898	9.96927	9.96957	9.96986
9.97159	9.97187	9.97215	9.97243	9.97271
9.97435	9.97461	9.97488	9.97514	9.97541
9.97696	9.97721	9.97746	9.97771	9.97796
9.97942	9.97966	9.97989	9.98013	9.98036
9.98174	9.98196	9.98218	9.98240	9.98262
9.98391	9.98412	9.98433	9.98453	9.98474
9.98594	9.98614	9.98633	9.98652	9.98671
9.98783	9.98801	9.98819	9.98837	9.98855
9.98958	9.98975	9.98991	9.99008	9.99024
9.99119	9.99135	9.99150	9.99165	9.99180
9.99267	9.99281	9.99294	9.99308	9.99322
9.99400	9.99413	9.99425	9.99438	9.99450
9.99520	9.99532	9.99543	9.99554	9.99565
9.99627	9.99637	9.99646	9.99656	9.99666
9.99720	9.99728	9.99737	9.99745	9.99753
9.99800	9.99807	9.99814	9.99821	9.99828
9.99866	9.99872	9.99878	9.99883	9.99889
9.99919	9.99923	9.99928	9.99932	9.99936
9.99959	9.99962	9.99965	9.99968	9.99971
9.99985	9.99987	9.99989	9.99990	9.99992
9.99993	9.99994	9.99995	10.00000	10.00000

	0	1	2	3	4
0	0.00000	7.24188	7.54291	7.71900	7.84394
1	8.24192	8.28332	8.32112	8.35589	8.38809
2	8.54282	8.56400	8.58419	8.60349	8.62197
3	8.71940	8.73366	8.74748	8.76087	8.77387
4	8.84358	8.85429	8.86474	8.87494	8.88490
5	8.94195	8.95060	8.95907	8.96739	8.97556
6	9.01923	9.02639	9.03342	9.04034	9.04715
7	9.08914	9.09537	9.10150	9.10756	9.11353
8	9.14780	9.15327	9.15867	9.16401	9.16928
9	9.19971	9.20459	9.20942	9.21420	9.21893
10	9.24632	9.25073	9.25510	9.25943	9.26372
11	9.28865	9.29268	9.29668	9.30064	9.30457
12	9.32747	9.33119	9.33487	9.33853	9.34215
13	9.36336	9.36681	9.37023	9.37363	9.37700
14	9.39677	9.39979	9.40319	9.40636	9.40952
15	9.42805	9.43107	9.43408	9.43707	9.44044
16	9.45750	9.46035	9.46319	9.46601	9.46881
17	9.48534	9.48804	9.49073	9.49341	9.49607
18	9.51178	9.51435	9.51691	9.51946	9.52199
19	9.53697	9.53943	9.54187	9.54431	9.54673
20	9.56107	9.56342	9.56576	9.56810	9.57042
21	9.58418	9.58644	9.58869	9.59093	9.59317
22	9.60641	9.60859	9.61076	9.61292	9.61508
23	9.62785	9.62996	9.63205	9.63414	9.63623
24	9.64858	9.65062	9.65265	9.65467	9.65669
25	9.66867	9.67065	9.67262	9.67458	9.67654
26	9.68818	9.69010	9.69202	9.69393	9.69584
27	9.70717	9.70904	9.71090	9.71277	9.71462
28	9.72567	9.72750	9.72932	9.73114	9.73295
29	9.74375	9.74554	9.74732	9.74910	9.75087

5	6	7	8	9
7.94086	8.02904	8.08700	8.14500	8.19616
8.41807	8.44611	8.47245	8.49729	8.52079
8.64009	8.65715	8.67350	8.68938	8.70465
8.78649	8.79875	8.81068	8.82230	8.83361
8.89598	8.90557	8.91495	8.92414	8.93313
8.98358	8.99145	8.99919	9.00679	9.01427
9.05666	9.06335	9.06994	9.07643	9.08283
9.11943	9.12525	9.13029	9.13667	9.14227
9.17450	9.17965	9.18475	9.18979	9.19478
9.22361	9.22824	9.23283	9.23737	9.24186
9.26797	9.27218	9.27635	9.28049	9.28459
9.30846	9.31233	9.31616	9.31996	9.32373
9.34575	9.34933	9.35288	9.35640	9.35989
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